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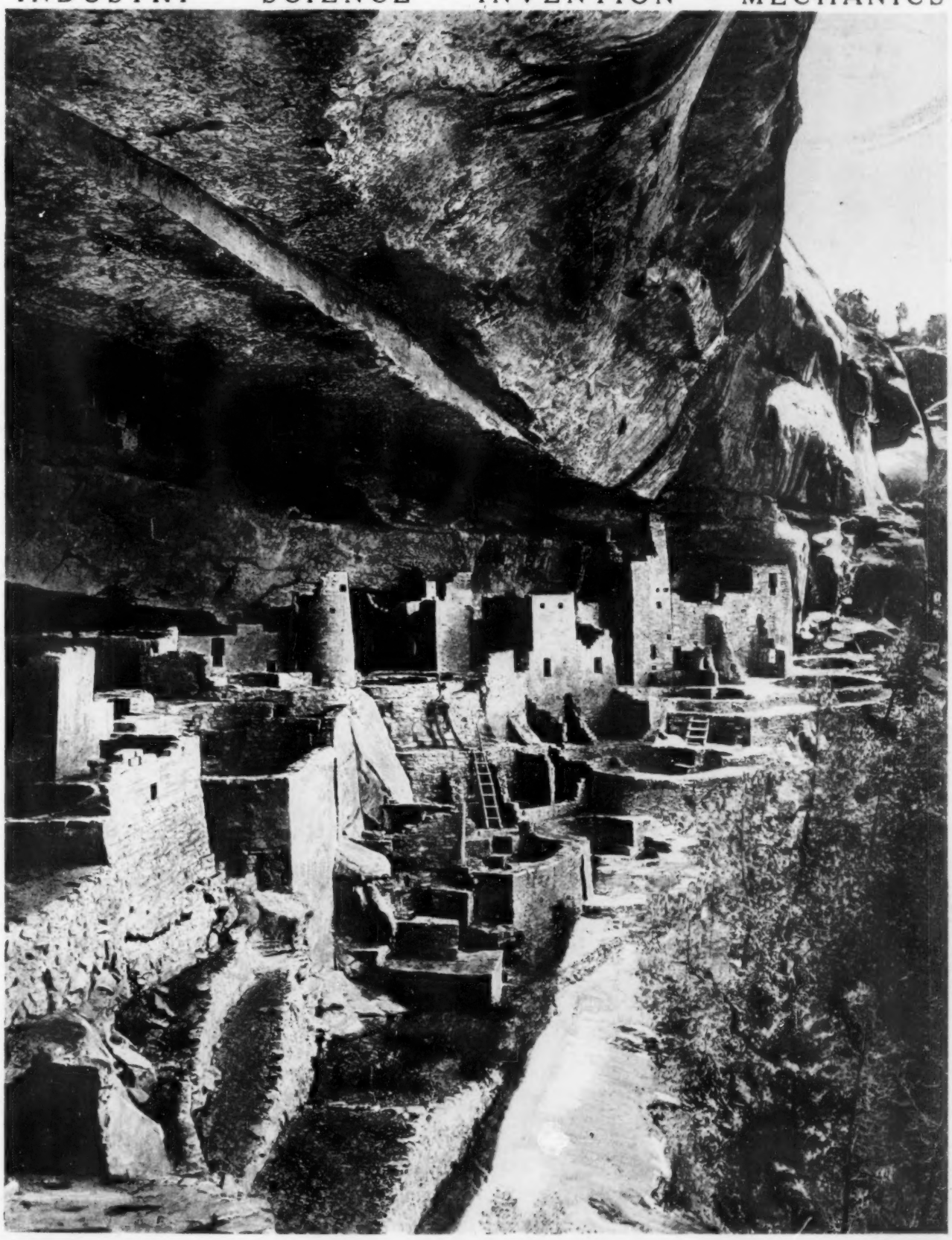
IN THIS ISSUE:

THE ARCHITECTURE OF THE MOLECULE
SOLVING THE SHORT-HAUL PROBLEM

SCIENTIFIC AMERICAN

A Weekly Review of Progress in

INDUSTRY · SCIENCE · INVENTION · MECHANICS



MESA VERDE CLIFF DWELLINGS: THE HOME OF COLORADO'S LOST RACE.—[See page 598]

Vol. CXXII. No. 22
May 29, 1920

Published Weekly by
Scientific American Publishing Co.
Munn & Co., New York, N. Y.

Price 15 Cents
$5.00 a year

Entered as second class matter June 18, 1879, at the post office at New York, N. Y., under the Act of March 3, 1879

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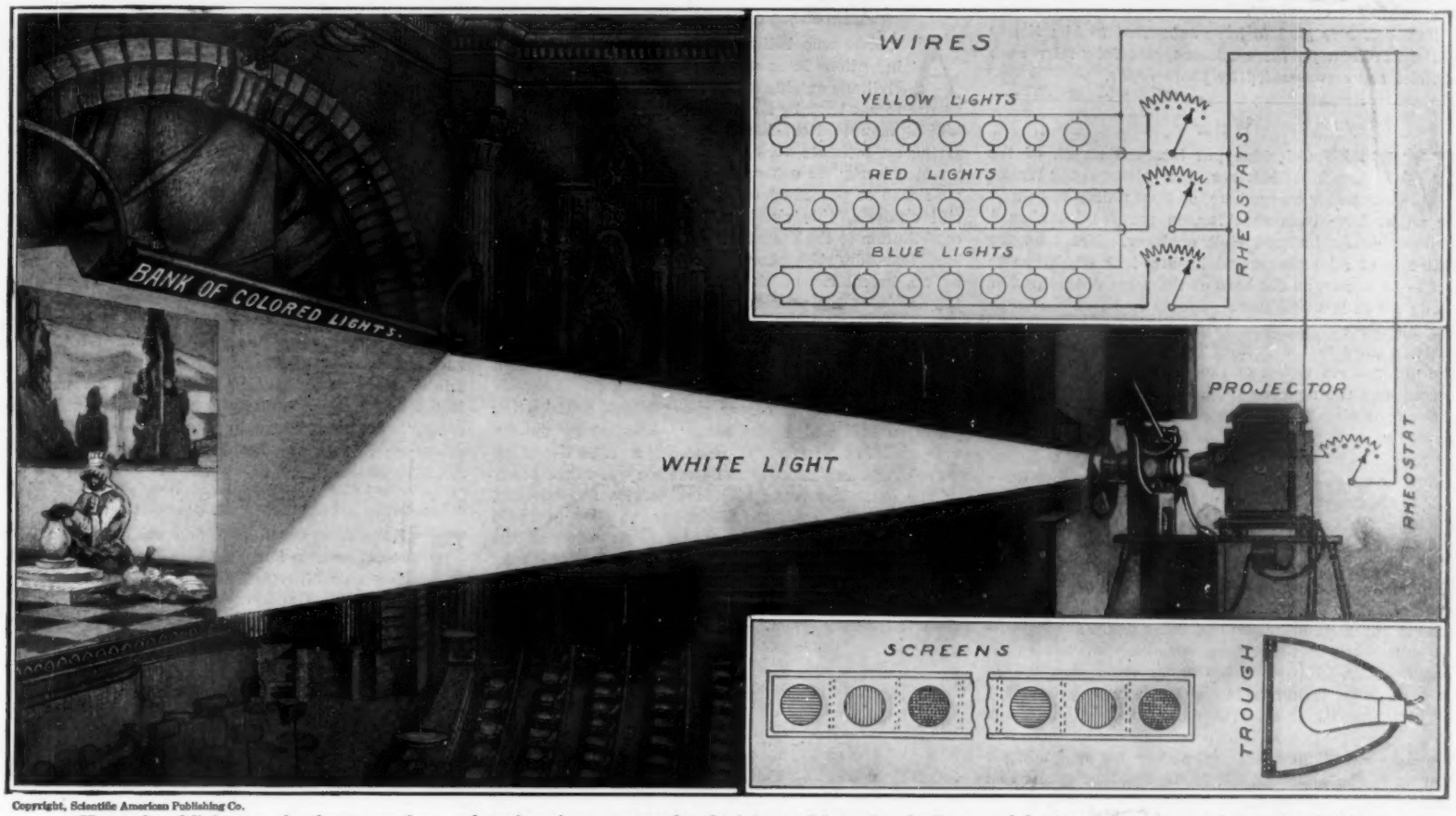
SEVENTY-SIXTH YEAR

SCIENTIFIC AMERICAN

THE WEEKLY JOURNAL OF PRACTICAL INFORMATION

VOLUME CXXII. NUMBER 22] NEW YORK, MAY 29, 1920 [15 CENTS A COPY $5.00 A YEAR



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How colored lights may be thrown on the usual motion-picture screen for obtaining striking colored effects, and details of the wiring and the colored lights

Adding Color to the Motion-Picture Screen

THE development of the motion-picture art is a story of continuous progress along mechanical as well as histrionic lines, a multitude of efforts for the good of the industry as a whole, and a wide interchange of ideas and suggestions such as has never been witnessed in any other industry. Day by day the men engaged in this relatively recent art find new and simpler and better ways of doing their work, and for the most part these innovations are given to the industry so that all may benefit. It is only in the matter of a few highly specialized developments that the use thereof is limited to a few.

Such a case is the recently patented lighting effect developed by D. W. Griffith, a pioneer in the field of dramatic motion-picture production who needs no further introduction to the cinema devotees of the world. Mr. Griffith, in his ceaseless quest for improvements in his art, has worked out a system of illumination for the usual screen which opens up a vast field of possibilities. Indeed, by means of his system it now becomes possible to beautify any plain black-and-white film to a surprising degree with little trouble and with only the expense represented by the operation of a dozen or even a lesser number of incandescent lamps.

This ingenious lighting system is simply a matter of throwing beams of variegated light on the usual screen while black-and-white pictures are being projected. Obviously, if blue light is thrown on the screen while black-and-white pictures are projected, the high lights which would ordinarily be white are now tinted in various shades of blue. It follows that other colors, such as red and yellow, may be thrown either separately or together, in the latter instance resulting in still other colors due to their blending effects. By varying the degree of brightness of the lamps of various colors through the medium of rheostats, the colored effects are still further modified to suit the momentary requirements.

The equipment for the lighting system consists of a suitable trough placed in front and above the screen as shown in the accompanying illustration, containing the colored lights, as well as a suitable wiring and switching system for controlling the lights. The trough is provided with partitions so that each lamp is concentrated on a colored screen through which its rays pass on to the screen. The switches, rheostats and other controls can be located in the operating booth or elsewhere.

Progress in Electrification of Swiss Railways

THE electrification of the important Swiss Federal Railway running south from Lucerne to the Italian border at Chiasso, thence into Italy to Milan (the Gotthard line), is progressing rapidly. It is now announced that the stretch of 25 kilometers through the Gotthard tunnel from Göschenen to Airolo will be operated electrically beginning this month, followed by the stretch north of the tunnel from Erstfield to Göschenen, 46 kilometers, in June; the line south of the tunnel from Airolo to Biasca, 73 kilometers, in September; and probably at a later date this year the stretch of 19 kilometers from Biasca to Bellinzona will be finished. The first trials with electrical equipment have been carried out through the Gotthard tunnel, and are stated to have proved very successful.

As rapidly as conditions will permit, the Federal authorities now plan to electrify practically all of the government-owned main line roads in the Confederation. It is planned to spread the work over a period of about 20 years. Within the next 10 years it is proposed to transform the line from Zurich, via Olten, Bern, Fribourg, and Lausanne, to Geneva. The part from Zurich to Bern, according to the present plan, will be started in 1922 and completed in 1924, and, in the following two years, it is thought that the section from Bern to Lausanne can be completed.

The electric locomotives for the Erstfeld-Bellinzona line are being built by a Swiss firm at Baden. The motor is constructed for the use of single-phase alternating current of 15,000 volts, with a frequency of 16 2/3, and will develop 540 horse-power. Each locomotive will carry four such motors, enabling it to develop a maximum speed of 75 kilometers per hour. The width of the gage is 1,435 millimeters; the diameter of the drive wheels, 1,350 millimeters; and the diameter of the running wheels, 950 millimeters. The total weight of the electric equipment and parts of each locomotive is 94.6 metric tons, and that of the purely mechanical parts, 58 metric tons. The latter equipment is being made by a Swiss locomotive and engine works, at Waterthur.

SCIENTIFIC AMERICAN

Published by Scientific American Publishing Co.
Founded 1845
New York, Saturday, May 29, 1920
Munn & Co., 233 Broadway, New York

Charles Allen Munn, President; Orson D. Munn, Treasurer
Allan C. Hoffman, Secretary; all at 233 Broadway

Entered at the Post Office of New York, N. Y., as Second Class Matter
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The object of this journal is to record accurately and lucidly the latest scientific, mechanical and industrial news of the day. As a weekly journal, it is in a position to announce interesting developments before they are published elsewhere.

The Editor is glad to have submitted to him timely articles suitable for these columns, especially when such articles are accompanied by photographs.

Water

WHEN Coleridge put into the mouth of the Ancient Mariner the plaint of "Water, water everywhere, and not a drop to drink," he might have been speaking, in part at least, as a philosophically inclined civil engineer. Not that the latter is at all embarrassed by any lack of drinkable liquid—he knows, as the hero of the poem did not, what to do about it when there appears to be no water fit for human consumption. Our attention is here directed rather to the first of the troubles set forth by the unfortunate victim of the albatross—the universal presence of the aqueous fluid.

Someone else than Coleridge—someone to whom we cannot refer by name—has pointed out explicitly that by far the greater portion of the human struggle for collective existence hinges about the control of water—keeping it out of the places where it is not wanted, and insuring its presence in those locations where it is desired. This is really no great exaggeration. Water is the universal substance, more than any other; it is alike of the greatest benefit and the greatest harm to mankind. It is free to flow where the laws of gravity tend to carry it; it freezes and melts again at our ordinary temperatures as does no other substance; in passing from place to place under the action of the various forces of nature it develops a vast power that may destroy us or effect a vast amelioration in our lives; it supports and transports floating objects; and coupled with all this potential agency for good and for bad, it is the universal life-giving fluid for plant and animal alike, yet in excess destroys both.

What engineering work of any consequence can be prosecuted without digging a hole in the ground—often a hole that extends below the level of the not-far-distant sea? Yet every time we do this, we are confronted with the certainty that the excavation will at least collect water, and possibly fill with water, if we do not adopt adequate measures of control.

Then we have the bridge—the earliest of man's engineering achievements. By its very nature the building of a bridge is a constructive conquest over the water. We cannot move the river away, so we make its presence ineffective.

Then there is the case where the water in the river or the lake or the bay will not stay where we want it—the bottom insists upon encroaching upon the space reserved for the navigable fluid. So we restore the water to its domain by removing the offending solids.

Or perhaps a Galveston or a Dayton flood bestirs us to confine the water to its proper sphere by means of a huge sea-wall or a gigantic system of reservoirs. Then we learn that New York will soon lack water to drink; so we build mighty dams that convert mountain valleys into lakes, and we tunnel the rocks, and bring water from the Catskills to the great city. Or perchance we have the Pacific coast or the central provinces of Canada, deficient in fuels; and we bethink ourselves of the power possibilities inherent in the transfer of a liberal quantity of water from a high place to a lower one—whence the vast hydroelectric developments of such regions as those named. Or mayhap our civil engineer goes to the other side of the world, to show that he can regulate, better than Nature herself, such a process as the annual Nile inundation.

As we thumbed over our files for the past year the other day, in search of an item which our index failed to reveal, it almost seemed to us as though the SCIENTIFIC AMERICAN of late has been given over wholly to projects for the development of water power, for the conservation of water supply, for the introduction of water into arid lands to make them fertile, for the prevention of destructive floods, for the better transport of goods by water, for the elimination of the water barrier between New York and New Jersey—for everything and anything in the world having to do with water. Then came the train of thought here outlined, with its explanation for this apparent over-balance in the direction of water engineering—an explanation couched in the three simple words, "Well, why not?"

A Lifetime of Naval Invention

ANYONE who believes that all of the important inventions in naval material have been made by civilians outside of the Navy Department should read a recent book by Bradley A. Fiske, entitled "From Midshipman to Rear-Admiral." As an autobiography giving an intimate view of the professional side of a naval officer's life ashore and afloat and written by a man who is possessed of keen powers of observation and analysis, this autobiography is a most valuable contribution to the literature of the United States Navy. But Rear-Admiral Fiske will be best known to posterity as an inventor who devoted his talents throughout the whole of his professional life to the improvement of naval material. Certain of his inventions have secured him a leading position among the men who have brought the navies of the world to their present high stage of material development.

Early in his naval career young Fiske, anticipating the vast field which was being opened up by the development of electricity, obtained a twelve-months' leave of absence in order to devote himself to the study of the art. Returning to active service aboard ship, his inventions began to follow one another in rapid succession, and we read of his development of the electric ammunition hoist, the electric training gear for guns and electric steering. The first ammunition hoist was installed on the "Atlanta," and the first electric training system served to operate an eight-inch gun on the "Chicago." Then followed the electrical range-finder which was installed on the "Chicago" in 1899. Readers of the SCIENTIFIC AMERICAN will recall these early installations, the first of their kind. The range-finder consisted of two telescopes, one at the bow and one at the stern of the ship, with a base line 300 feet in length. This was followed by a second installation on the "Baltimore," in which the operator moved a pointer along some resistance wires until the needle of a volt-meter came to zero when the range reading was taken.

Admiral Fiske tells us that he was "able to measure distances with sufficient accuracy for the short ranges then used," and it will make some of us smile to learn that "in October, 1890, 2,000 yards was considered to be about the limit of range for accuracy of gun fire." We think it is unquestionable that young Fiske was the first to apply automatic range-finding successfully in naval gunnery.

But the invention with which Fiske's name is most intimately associated is the development of the telescopic gun-sight. This patent, taken out in 1890, is for a method of pointing a gun, located on a rolling platform, by means of a telescope on the same platform, the telescope being capable of being placed at a vertical angle to the gun corresponding to the range. Admiral Fiske contends that this patent underlies the whole practice of modern naval gunnery, and that it distinctly antedates the director-firing system of Admiral Sir Percy Scott. We consider that he is justified in his claim. Fiske was the first to use a telescope on a gun which was so attached to the mount that the telescope was not carried back with the gun in its recoil, but remained stationary on the mount.

In equipping the "Baltimore" with his second range-finder, Fiske made use of telephones secured to the telescopes and reading instruments, so that conversations could be carried on between the observers and the man who read the range indications on the volt-meter. This, he claims (and so far as we know the claim is correct) was the first installation of the telephone ever made on board any ship. Then followed the stadimeter, the engine telegraph and the speed-and-direction indicator.

Tribute is paid in this autobiography to Admiral Sims, to whose courage and initiative, backed up by the powerful influence of President Roosevelt, was due the introduction into our navy of modern methods of gun-firing. We think that a just estimate of the situation is that Fiske invented the telescopic sight, which is the basis of director-firing; that Sir Percy Scott gave Fiske's invention its first complete application in his method of director-firing, showing thereby the great scope of its application; and that Admiral Sims was responsible for the adoption of this system throughout the United States Navy.

We should be guilty of a serious omission if we said nothing of Fiske's development of the torpedo plane, which, if the Admiral's forecast is correct, is destined to have a profound effect upon the navies and naval warfare of the future. He is one of those who, like the British Scott and Fisher, believe that the day of the capital fighting ship has passed. The SCIENTIFIC AMERICAN does not believe we have reached that point just yet, if indeed we ever shall.

The closing chapters of the book are exceedingly timely, since they tell of this able and patriotic officer's struggle, as Aide to Secretary Daniels, to impress upon that individual the alarming condition of unpreparedness of the Navy. It took courage to tell the Secretary to his face, and repeat afterward to the world at large, that it would take five years to put our Navy in such a condition of preparedness that it could meet successfully a first-class naval power. For his patriotic candor and courage, Admiral Fiske was subjected to the same indignities which our present Secretary is busy heaping upon that fearless and patriotic officer who, like Fiske, has done so much for the Navy, Admiral Sims.

Arthur Von Briesen

THE sudden death of Arthur von Briesen marked the close of a long and successful life as lawyer and philanthropist. Born in 1843, in Prussia, he came to the United States in 1858, and in 1868 graduated from the New York University Law School, which in later years conferred upon him the degree of LL.D. Von Briesen was a man of intensely strong convictions and of equal courage in carrying them out; and it was entirely in agreement with these characteristics that, at the outbreak of the Civil War, he should have at once enlisted in the service of his adopted country. He held the rank of Sergeant of Company B, First New York Volunteers.

At the close of the war he spent some eight years on the staff of the SCIENTIFIC AMERICAN as examiner and patent attorney, where he is remembered for his keen intelligence, forceful personality and great power of application. Later he took up private practice as a patent attorney, and he quickly established himself as one of the ablest and most successful men in this profession.

Underneath his strong and aggressive personality there beat a kindly and sympathetic heart, particularly for the less successful and the unfortunate in the community. The story is still told by a contemporary of his in those early days, of an owner of a patent on a new method of paving, who came to young Von Briesen and told him that a wealthy firm of contractors was using his system for certain paving in Central Park without his permission. Von Briesen took the case into the courts, won it, and made either a nominal or no charge for his services. It was in the same spirit that he began his long service of twenty-five years as president of the Legal Aid Society, whose existence was due entirely to Von Briesen's initiative. His earnest labors in behalf of poor litigants is one of many claims which Von Briesen established to the respect and gratitude of the community.

Among other offices he held that of president of the Citizens' Union, in 1896; chairman of the New York Roosevelt League, 1906; chairman of the Ellis Island Investigation Commission, 1903; and president of the National Alliance of Legal Aid Societies.

Electricity

Safety Cartridge-Fuse Remover.—For removing and replacing cartridge fuses of ½-inch to 1½-inch diameter an electric company has recently developed a safety cartridge-fuse remover. This tool is made of a special insulating material which is said to be extremely tough but which will not warp or absorb moisture. The construction of the fuse remover resembles that of a pair of pliers, except that the movement of the handles is multiplied in the gripping jaws, resulting in simplicity of operation, only one hand being required.

Play 'Phones for Youngsters.—Quite an interesting development in telephony is a new three-wire wall set which operates on two ordinary dry cells. The 'phone itself is built for the use and pleasure of youngsters. The installation is very simple, as the 'phones fasten to the walls with two screws and there is nothing more technical for the boy to do than to follow simple instructions in connecting the wire with the posts on each 'phone box. The set will operate up to 1,000 feet, instead of the usual 100 or 200 feet, if two additional dry cells are employed.

Commercial Application of Radiophone.—The Public Service Company of northern Illinois is installing wireless telephones at its Blue Island and Joliet stations, the intervening distance as the crow flies being only about 25 miles, according to *Electrical Review*. The two stations tie-in together and also are interconnected with the Fisk and Quarry street stations of the Commonwealth Edison Company in Chicago. The wireless system will have a radial power of about 100 miles, and will be used primarily during such times as the metallic telephone lines are out of service, due to weather or high-voltage system trouble.

A 11,000-volt Submarine Cable.—From the *Teknisk Ukeblad*, we learn that a Swedish firm has supplied two high-tension cables for the Skars power station, near Kristiansund, in Norway. Each cable is nearly two miles long and weighs 52 tons. It has a sectional area of copper wire of 350 square millimeters in three separate conductors. These are insulated with impregnated paper and compressed to form a cylindrical cable, wound with impregnated paper and surrounded with 3/32-inch thick lead tube. This is further strengthened with impregnated jute, galvanized steel wire, and a final coat of impregnated jute. The diameter of the finished cable is 2½ inches. This cable was tested in the factory with a pressure of 40,000 volts, but when placed in position it will again be tested to a pressure of 25,000 volts.

An Electric Vehicle with Regenerative Braking.—Sometime ago Dr. Charles P. Steinmetz, whose name is so well known, announced the consummation of his many years of study and experimentation in electric vehicles in the form of a light-weight electric truck. The new vehicle is distinguished from the conventional types by the method of motor control, which gives the motor compound characteristics by a storage cell floating on the field circuit. The result of this control is claimed to be speed maintenance, quick starting, power saving in the field at large currents and the feature of regeneration both on down grades and on stopping. The field and armature of the motor revolve in opposite directions, each driving one of the car wheels. In this way motor weight is saved, the differential is eliminated and the truck is as a result simpler and more compact.

Locating Rifle-Barrel Flaws by Magnetic Analysis.—In a paper recently prepared by the Bureau of Standards, there is described an interesting investigation which was undertaken for the purpose of determining whether an application of magnetic analysis was practicable for the detection of flaws in rifle-barrel steel. By means of apparatus especially constructed for the purpose, a large number of bars were explored for magnetic uniformity along their length. The results demonstrated that the method is amply sensitive for the selection and locating of flaws. Further study is necessary to determine to what degree the sensitivity should be reduced in order not to cause the rejection of material which is satisfactory for all practical purposes and also to determine the type and magnitude of the effect which will be produced by a pipe.

Science

A Remarkable Wind Velocity.—Mr. W. R. Gregg reports in the *Monthly Weather Review* that during a pilot-balloon flight over Lansing, Mich., on the morning of December 17, 1919, a wind of 83 meters per second (186 miles an hour) was observed at an altitude of 7,200 meters (about 4½ miles). So far as known, this is the highest wind speed ever observed in the atmosphere of altitudes less than 10 kilometers. Exactly the same velocity was recorded by an anemometer on Mount Washington in 1878, but anemometer readings at high velocities are always much in excess of the true speed of the wind. At great altitudes much higher velocities undoubtedly occur. Cirrus clouds have been observed to move at speeds of 200 miles an hour and upwards, and the drift of meteor trails seem to indicate that the highest winds of all occur far above the cloud level, though the interpretation of such observations is a matter of controversy.

Lexicography in the Department of Agriculture.—Official lexicography is not always happy in its results. It is to be hoped that the U. S. Department of Agriculture will use more discretion than some other branches of the Government have displayed in this line in a task upon which it has lately embarked, viz., that of prescribing spellings, pronounciations and definitions for agricultural terms that have not yet found their way into the ordinary dictionaries. It appears that the Bureau of Animal Industry and the Division of Publications have conspired to set in order the vocabulary of agriculture; primarily for the guidance of writers in the Department itself, but lists of terms and definitions will, it is announced, be supplied to the publishers of dictionaries with the view to obtaining uniform national usage. The Department has inaugurated its new enterprise by deciding that "corn belt" is preferable to "corn-belt" or "cornbelt."

Facts About Einstein.—Conflicting statements about the nationality of Prof. Einstein, of relativity fame, have appeared in the daily press, and Einstein himself vouchsafed some facetious remarks on the subject in the London *Times* when popular interest in his theory was at its height. From a more recent interview with Einstein, published in the London *Daily Chronicle*, it appears that he is a German by birth, but went to Switzerland at an early age and was naturalized in that country. For some years he was professor of physics at the Polytechnikum, in Zürich, and also, for a short time, at the University of Prague. Shortly before the late war began he was called to the University of Berlin, where he still is, being at the same time director of the Kaiser Wilhelm Institute for Physical Research. He is now little more than forty years of age, and he conceived the outlines of his theory of relativity at the early age of eighteen. He was only twenty-seven when he presented it to the world.

An Important Center of Radio Research.—A circular of the Bureau of Standards calls attention to the fact that, besides its own radio laboratory, there have been maintained at the Bureau two other laboratories for radio research: one conducted by the Signal Corps of the Army and the other by the Navy. The three laboratories have been working in close coöperation. Moreover, the French Scientific Mission, which visited this country during the war, made its headquarters at the Bureau of Standards and deposited a large amount of French radio material there. The radio work of the Bureau is divided into two sections; viz., radio research and testing, and radio development. The first includes the investigation of the properties and phenomena of audio waves and antennas, electron tubes and amplifiers, radio telephony and associated problems, such as multiplex telephony, insulating materials and the testing of radio instruments. The development work includes that conducted on the radio direction-finder and its application to aerial and navigational uses, besides other undertakings. A notable development of the work of the Bureau in this field is its coöperation with the research laboratories now maintained at many universities. The Bureau has been able to offer suggestions for research work, besides supplying advice on particular problems, furnishing data and publications, and standardizing apparatus for the laboratories. It has also read and criticized papers and books prepared by the university research workers.

Industrial Efficiency

Direct Connections with Poland.—The Polish Government is looking forward to the early establishment of a steamship line between the United States and Danzig, to handle the large emigration movement that will undoubtedly ensue.

British Columbia Sawmills have received an order from the British Government for five million feet of railway ties for the United Kingdom and it is expected that further orders will follow. The Province's mills cut seventy million feet for the British Government last year.

Coal in Saskatchewan.—The coal deposit at Lampman, Sask., Canada, is believed to be one of the best of its kind in the world, and one of the greatest assets of the province, according to the investigators who recently made an examination of the location. They estimated that there are 32,000,000 tons of coal in the two and three-quarter sections of land in which the coal is located.

Weaving for Disabled Men.—It is reported from Great Britain that various textile manufacturers and the General Union of Textile Workers have put forward for consideration a scheme whereby unemployed disabled ex-service men will be trained in weaving. It is proposed that during the first ten weeks of training each man should receive £2 from the Government and £1 from the employer; during the subsequent four weeks £3 from the employer or such higher amount as the worker may be able to earn. It is believed that ten weeks would be sufficient to make the men efficient.

Synthetic Fuel Oil.—It is reported from Germany that wartime experiments showed that the distillation of lignite at a high temperature gave a liquid coal tar which contained certain ingredients suitable as a substitute for gasoline, kerosene, and lubricating oils. Through a new process benzine and kerosene can be obtained from liquid coal tar, which has been distilled from lignite at a lower temperature, and all industries using lignite are urged to set up facilities for generating this liquid coal tar and thus secure synthetic products to supply the lack of the natural products. It is interesting to remark that at this time when there is a shortage of fats in central Europe, German newspapers are advertising a liquid soap containing a percentage of alcohol for shaving purposes. This is undoubtedly a by-product.

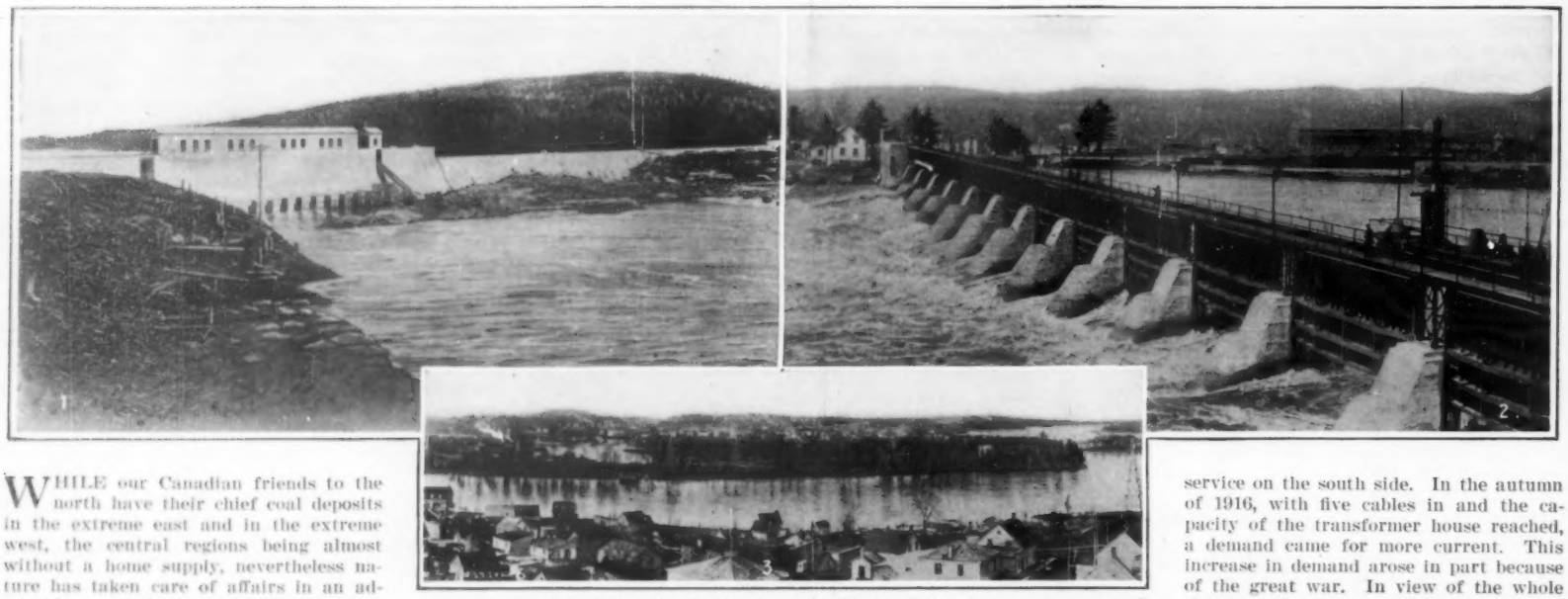
Court of Labor Arbitration.—There has been established in Great Britain what is known as the Industrial Court. This court is a standing arbitration tribunal, the provision of which was one of the recommendations of the Committee on Relations between Employers and Employees, better known as the Whitley Committee. It is the desire of the British Government that trade disputes should be settled as far as possible by negotiation between employers' associations and trade unions. In cases where agreement is impossible recourse can be had to the Industrial Court, provided consent of both parties to the dispute is forthcoming. One of the advantages of reference to a standing court is that the experience of the members of the court in dealing with difficulties in other trades is placed at the disposal of the parties to a particular dispute.

Income Tax Information Service.—The establishment by the Government of an Income Tax Information Service is responsive to the demand of taxpayers in general, and more especially lawyers, accountants, engineers and others who require in their professional work the most complete and reliable knowledge of tax practice. The Service will consist of regular weekly Bulletins containing current decisions and rulings upon questions arising in the administration of the Revenue Acts of 1917 and 1918, as well as under the prior income tax laws, and bi-monthly cumulative Digests. A Cumulative Bulletin in which the contents of the weekly Bulletins are to be consolidated will be issued semi-annually. The Service of Information is compiled and edited by the Bureau of Internal Revenue and is printed by the Government Printing Office. The service costs $2.00 per year, and subscriptions should be addressed to the Superintendent of Documents, Government Printing Office, Washington, D. C.

The Overhead Cable Crossing

Largest Electric Transmission Span in the World, at Three Rivers, Quebec

By J. F. Springer



1. La Loutre dam, far up the St. Maurice, which blocks off the greatest power reservoir in the world. 2. Dam and control gates at Shawinigan Falls, 20 miles from the crossing of the St. Lawrence. 3. The town of Shawinigan Falls which has grown up about the dam.

Some features of the generating system which sends current over the St. Lawrence on the longest transmission span ever constructed

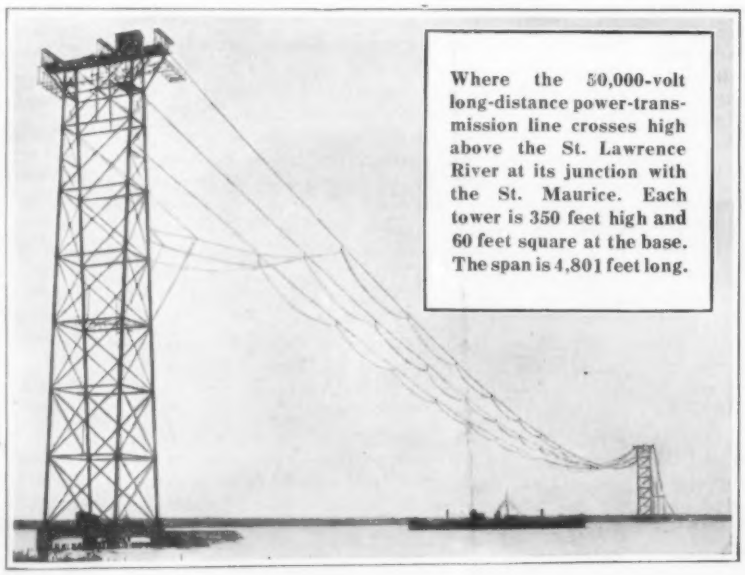
WHILE our Canadian friends to the north have their chief coal deposits in the extreme east and in the extreme west, the central regions being almost without a home supply, nevertheless nature has taken care of affairs in an admirable way. In between the extremes, particularly in the populous districts of Quebec and Ontario, are numerous water power sites which have already been economically developed or which may be so developed. One of the great developers of Canadian water power owns or controls a combined horse-power generating capacity in the neighborhood of 480,000, and has in contemplation a further development which will bring the grand total to 600,000 horsepower. These power plants are all located on the St. Maurice River and all within eighteen miles of one another.

The St. Maurice flows southeast and south through central Quebec and enters the St. Lawrence on the north side near a station on the Canadian Pacific Railway known as Three Rivers. The head waters are located near the dividing ridge which separates the Laurentian watershed from that of Hudson Bay. Pretty much the whole of the drainage area of the St. Maurice is wooded and to a considerable extent unsuited to agriculture. For years to come, its chief service to mankind will be concerned in the useful function of gathering the water and sending it down the valley to be utilized in the generation of electric current. This current is used in operating lights and power units in a considerable district. The principal development is at or near Shawinigan Falls, and a score of miles northwest of the point where the St. Maurice empties into the St. Lawrence.

The latter river thus opposes a natural barrier to the transmission of current to the mining and other districts on the south side of the wild stream. But this barrier has not been an insurmountable one. For some years the company has been transmitting current over two lines to a switching station at Victoriaville, thirty-five miles south of the big river. At this point the lines branch, the one carrying current fifty miles to Sherbrooke and intermediate points and the other transmitting energy to the Thetford mining district. From the power plant the current was despatched to the St. Lawrence River at a voltage of 50,000, where the pressure was stepped down to one-half. It then passed beneath the waters of the great stream to the south side where it was stepped up to the original 50,000 volts and transmitted to Thetford and Sherbrooke.

The under-water transmission was carried out by means of submarine cables, since at first the demand for power was small and did not seem to warrant the great expense incidental to an overhead crossing. However, the demand steadily increased, so that the transmission begun with a single cable required by 1916 as many as five. Two cables were of three-conductor size and three of one-conductor. At this stage, the capacity of the transformer house was reached. It was then necessary to face once more the question of the kind of crossing.

Cables may, of course, be used up to any total, if the voltage is kept down. However, experience had shown that the bed of the St. Lawrence was, at this point, not especially well suited for a cable crossing. The chief characteristic unfavorable to cables seems to be the trench-like character of the main channel of the stream. The river bed drops gently from both margins towards the center for a considerable distance. Then the bottom deepens suddenly. The cables do not in this region lie snug on and in the bottom, but hang in a partial suspension. The swinging of the cables results in wear on the armoring and a burning out at the suspension points. The current is strong enough to carry the cables downstream. In fact, the strength of the current has, at times, been sufficient to drag cables loose from their moorings. The ice in the winter season generally put at least one of the cables out of commission. At times, it was found necessary to set up pole lines for temporary transmission over the ice-covered stream in order to maintain the service on the south side. In the autumn of 1916, with five cables in and the capacity of the transformer house reached, a demand came for more current. This increase in demand arose in part because of the great war. In view of the whole situation the decision was made to substitute an overhead crossing rather than attempt to increase the capacity of the submarine one.



Where the 50,000-volt long-distance power-transmission line crosses high above the St. Lawrence River at its junction with the St. Maurice. Each tower is 350 feet high and 60 feet square at the base. The span is 4,801 feet long.

Before committing itself to a single plan for the overhead crossing, the company investigated two alternatives. First, a three-span crossing might be made at Pont-du-Lac, some six miles up the river at the downstream end of Lake St. Peter, as a certain great enlargement in the St. Lawrence is called. Each span would be 2,200 feet long. Second, there was the alternative of a single-span crossing connecting the existing cable houses. This involved the suspension of transmission lines 4,800 feet between supporting towers.

The Pont-du-Lac location had certain points in its favor. The spans were moderate. The towers need not be excessively high. And the direct cost of the crossing would probably have been less than for the single one at Three Rivers. However, fifteen miles of high tension pole line would have been required to connect up with the lines already in existence. And certain of the towers would have been more or less inaccessible from the shores in the spring and fall, when the river is full of floating ice. The decision for the single span was made, in spite of the fact that hitherto none of that length had ever been constructed.

As the towers stand on the north and south shores, the span is 4,801 feet long. The two towers are each 350 feet high and 60 feet square at the base. The upstream and downstream faces are tall trapezoids tapering from 60 feet at the bottom to 14 at the top. At the summit of each tower is a cross-arm 100 feet in length which is arranged perpendicular to the crossing. It is of equal width with the upstream and downstream faces at their summits and projects 20 feet, cantilever style, beyond them. Three double-groove sheaves are set in each cross-arm—one at each end and one in the middle. Three cables pass over these sheaves, which are 8 feet in diameter. Each cable may roughly be divided into three lengths—two anchor sections and the section over the river. However, the anchor sections are not single ropes but consist of two cables each. These are yoked to the river sections. The steel ropes which span the river are 1⅜ inches in diameter.

The towers stand, each, on four piers of reinforced concrete. Each pier is circular and has a diameter of 11 feet. Reinforced concrete beams of large size connect pier to pier, uniting the whole into a single structure. At normal water level the pier heads stand 14 feet above the surface.

(*Continued on page 606*)

The Dendrograph—An Instrument That Keeps Tabs on Tree Growth

By Dr. Wm. A. Murrill, N. Y. Botanical Gardens

IT is a matter of common observation that some trees, like the pines, poplars, willows, and soft maples, are of rapid growth; while others, like the hard maples and most of the oaks, grow more slowly and produce wood of greater strength and firmness. The dendrograph is an instrument designed to record minutely and accurately all changes in the size of the trunk of a growing tree. When once properly attached to the trunk, it requires no further attention except the weekly winding of the clock-work and the insertion of a new record sheet on the recording cylinder.

Such an instrument was installed on March 4 of the present year on a young sugar maple about a foot in diameter growing in the New York Botanical Garden. So much interest has been exhibited in this experiment by the visiting public that it has been necessary to erect a wire cage about the tree to prevent undue interference with its growth and the operation of the recording apparatus.

The most conspicuous part of this instrument is the recording drum with its record sheet, protected by a tin cover attached to the trunk and caused to rotate by clock-work; but the essential feature is a yoke composed of slotted bars of bario—an alloy with a very low temperature coefficient—held in place by upright "fingers" of spring brass wire, which hold the yoke in position without exerting any notable pressure on the tree.

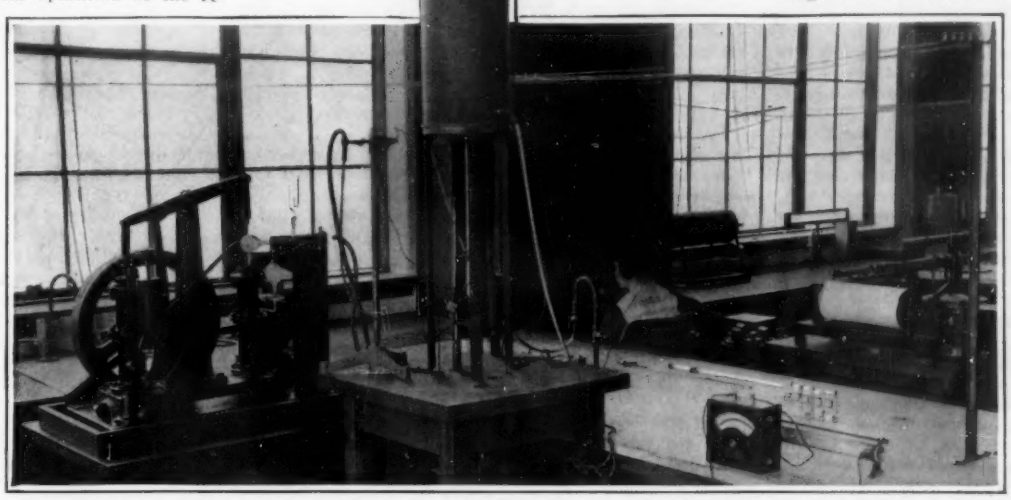
A belt of wooden blocks, serving as a support for the essential parts of the apparatus, is clasped about the trunk in such a way as to touch it at only a few points and therefore to interfere as little as possible with its growth. These blocks are placed horizontally about a yard above the ground, the block bearing the recorder being on the south side of the tree. Changes in the distance between the contact screw on the opposite side of the trunk and the arm of the bearing lever are accurately registered on the drum by the recording rod and indicate changes in the size of the tree at that point. In other words, a curve of growth is traced on the revolving drum as it passes beneath the point of the rod, whose position is gradually changed as the trunk expands in the process of growing.

The usual tank car and a steam pump mounted alongside the tank go to make this railroad fire-fighting equipment

A Fire-Fighting Equipment on Rails

A MIDDLE-WEST railroad which has been more or less troubled with fires along its right-of-way for some time has gone to work and constructed the ingenious fire-fighting equipment which is depicted in the above view. Upon one of the usual tanks cars is mounted a simple steam pump alongside the reservoir. The pump is operated from the locomotive, and by means of hose connections on both sides of the tank the crew can direct three streams of water at the same time, thus providing a volume of water adequate to extinguish forest fires of considerable area.

This case is very much in line with what other railroads have done to prevent conflagrations in the first place, and to check them in the second, in woods and forests along their right-of-way. Railroads passing through thickly forested regions are providing their locomotive funnels with spark arresters of various designs in order to reduce the fire hazard to a minimum. —By *G. Orb.*



Modified Rosenhain furnace for thermal analysis of metals and especially for determining the thermal and critical points of steel

Determining the Heating and Cooling Curves of Metals

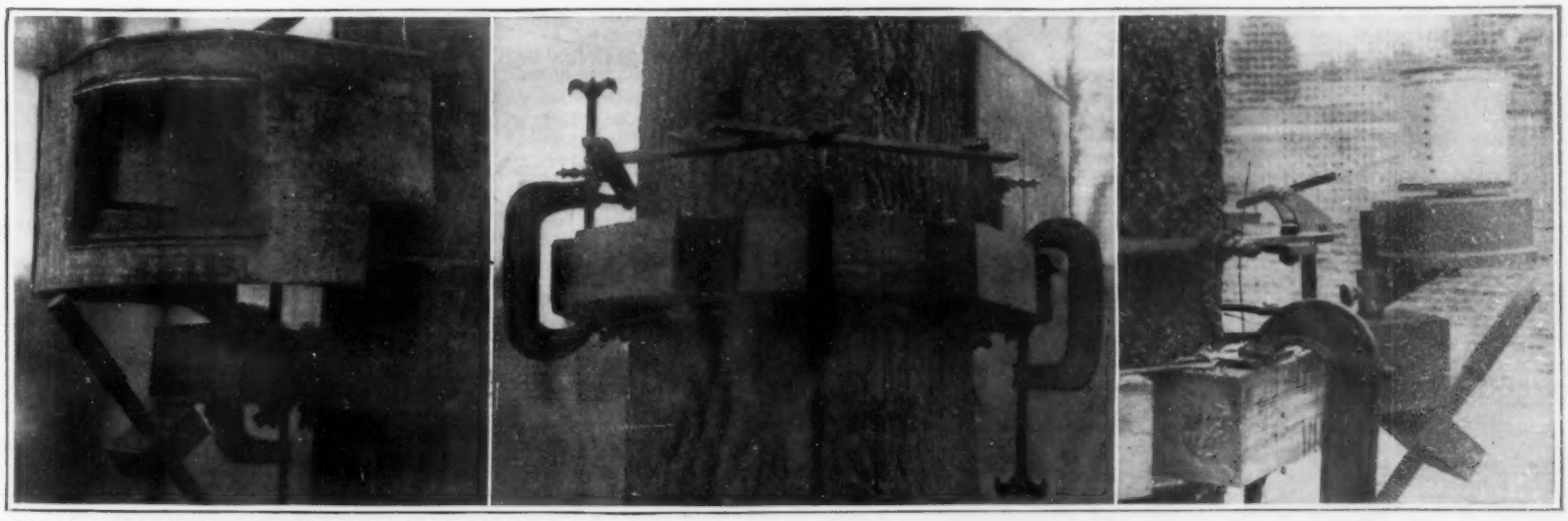
By S. R. Winters

THE construction of a new type of furnace for taking heating and cooling curves is the result of the joint scientific efforts of F. E. Mann, Miss H. G. Movius, and H. A. Wadsworth of the National Bureau of Standards. Although the laboratory equipment, as shown in the photograph herewith, is a modified form of the Rosenhain furnace, a novel method for making thermal analysis has been evolved.

The newly-designed furnace obviates the necessity of varying the heating current. Changes in temperature of the objects under observation are produced by raising and lowering the sample in the furnace kept at constant temperature. Designed especially for determining the thermal critical points of steel, the method developed by the Bureau of Standards is also economical in practice.

The usual method of recording inverse heating and cooling curves is by the use of a chronograph, observing the consecutive time intervals. This practice necessarily entails the use of an expensive apparatus, not easily available at present. Of additional consideration is the time element, from one to two hours required to tabulate the time intervals from the chronograph sheet. As an economical substitute, the Bureau of Standards has found two stop watches as accurate and convenient in performance as the chronograph. Likewise the new process is a time-saving one.

Although a modified form of the Rosenhain thermal-analysis furnace, the Bureau of Standards deviated from his principle of construction in two essential particulars: A gravity-drive rate control was adopted, and the sample introduced through the bottom and cold end of the furnace. The designers are of the opinion that they have surmounted the difficulties indicated by Rosenhain in the construction of a furnace intended chiefly for the thermal analysis of metals by the inverse-rate method, namely, the uniformity of the rate of heating or cooling being inadequate for the degree of accuracy desired. Moreover, it is believed, judging from the volume of requests for information on the new type of furnace, that manufacturers will freely adopt and in all probability will find ways to improve the construction. —By *S. R. Winters.*



First two photographs, Copyright, Keystone View Co.; last photograph, Copyright, Kadel & Herbert

Three views of the dendrograph, showing the case with the glass window, the belt of blocks, and the recording mechanism exposed to view

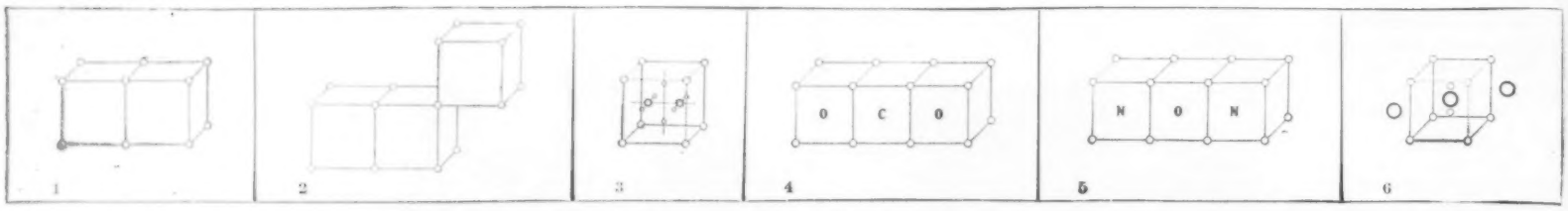


Fig. 1. The oxygen molecule: two octets, with two pairs in common. Fig. 2. The ozone molecule, in which the third octet has but one pair in common with the one to which it is joined. Fig. 3. The nitrogen molecule, which shows an octet, but in which the internal electrons depart from the usual simplicity. Fig. 4. The molecule of carbon dioxide, in which the carbon contributes four electrons, and each oxygen atom six, to the formation of the three octets. Fig. 5. The molecule of nitrous oxide, in which the oxygen supplies six free electrons and each nitogen atom five. Fig. 6. Molecule of water, in which each of the hydrogen atoms, whose presence is indicated by the nuclei at right and left, has supplied a single electron to make up the octet.

How some of the simpler molecules are constructed, according to the ideas of Dr. Langmuir

The Architecture of the Molecule

Some of the Things Which the Langmuir Postulates Tell Us About the Chemical Compounds

By Oscar R. Foster

IN the previous discussion of the electronic conception we noticed that the outer layers of the electrons that go to make up an atom tend to form groups of eight; and to these groups, represented diagrammatically as cubes, we gave the name of octets. It is to be emphasized that when octets are adjacent to one another in the architecture of the atom, the theory indicates that they may hold in common one or two *pairs* of electrons, but never a *single* electron. Referring to Fig. 7, for instance, we have one pair of electrons held in common by the two octets, while Fig. 8 shows a molecule in which two pairs are so held. If p be the number of pairs held in common, obviously $2p$ is the number of individual electrons so held.

The outer layer of electrons is the only part of the atom which is available for the formation of octets. The nucleus and any inner layers which the atom may possess remain always undisturbed in their relative arrangement. We may call the outer layer the shell of the atom. Usually, for the sake of clearness, only these shells will be represented in our diagrams. However, in the case of an atom like that of hydrogen, which has so few electrons that it possesses no shell at all, it is necessary, in order to show the presence of such an atom, to represent its nucleus.

The property which causes octets to share pairs of electrons is called covalence. Atoms unite because each one which has an insufficient number of shell electrons to form a complete octet endeavors to complete its octet by sharing pairs with the finished or unfinished octets of other atoms. This is indeed the cause of all chemical activity—and an element whose octets are complete, like argon, neon, etc., is chemically inert.

The octet-forming propensity of the atoms enables us to picture the molecules of compounds. Several surprising results follow as a result of this tendency. In order to understand these we must first apply a simple mathematical formula. Let n stand for any number of octets: $8n$ will be the number of electrons in these. But in the case of a molecule, since pairs of electrons are held in common, we have counted twice those electrons which are thus at the same time tied up in two octets. The net actual number of distinct electrons in the shell of a molecule will therefore be $8n - 2p$.

The electrons of the shell of any molecule are the available electrons of the shells of the constituent atoms. Referring to a list of atomic numbers, such as that printed in part in the editorial comment on the former article (SCIENTIFIC AMERICAN, May 15th, page 544), and deducting the two electrons which we know must go to make up the inner layer around the nucleus, we see that the number of available electrons is 4 for the carbon atom, 5 for nitrogen, 6 for oxygen, 7 for fluorine, etc. Let e represent the total number of available electrons in the components of any molecule whose formula is known. We then have:

$$e = 8n - 2p \qquad (I)$$

By algebraic transformation we have from this:

$$p = \tfrac{1}{2}(8n - e) \qquad (II)$$

We may again summarize here that p is the number of pairs of electrons held by octets in common; n is the number of octets in the molecule; e is the total number of available electrons in the component atoms. The numerical value of p gives us the covalency of the substance whose molecular form we are discussing.

THE present article is a direct continuation of Mr. Foster's "The Architecture of the Atom," in which, two weeks ago, he put before our readers a simple exposition of the Langmuir postulates as to the constitution of matter. In his second discussion herewith, Mr. Foster shows how the principle of grouping the electrons into octets works out in the formation of molecules of elements and compounds, and makes it clear that if the Langmuir theories are found to be valid, we have a remarkable means for predicting whether a compound of given formula can exist.—THE EDITOR.

This simple equation may be easily applied to the molecules of the elements discussed in the previous paper, though a notable exception to this rule is nitrogen, the considerations which govern the structure of this molecule being too complicated to be discussed in this elementary exposition of the subject. We shall, however, confine our attention here to the structure of the molecules of compounds, and proceed to build these in accordance with the theory as summarized in equation (II).

Consider the substance carbon dioxide, CO_2. The carbon atom has six electrons, of which two cluster about the nucleus while four are available for octet formation. Of the eight electrons in an oxygen atom six are similarly available. The two oxygen atoms plus the carbon atom will therefore supply 16 available electrons, and (II) becomes:

$$p = \tfrac{1}{2}(8n - 16) \qquad (III)$$

Our task is now to find an integer value for n which shall make p also an integer, subject to the further restriction that n must not be so large that it would be impossible to make up n octets out of 16 electrons. An equation of this sort is called a Diophantine equation, and is not solved by any such direct and general attack as the ordinary algebraic equation. For such a simple case as the one before us, the best thing is to try successive values 1, 2, 3, etc., for n; and when we do this, we find that $n = 1$ and $n = 2$ are ruled out because they would make p in the one case negative and in the other case zero, while $n = 3$ gives $p = 4$ and satisfies all the demands of the problem. So the number of pairs of electrons held in common by octets of the CO_2 molecule is 4, while the number of octets is 3. Knowing this, a little ingenuity is sufficient to enable us to diagram the molecule, as seen in Fig. 4.

If we apply the same procedure to the compound nitrous oxide, N_2O, we find that each nitrogen atom supplies five available electrons, while the single oxygen atom is responsible for six. So here also $e = 16$, and we have, as before:

$$p = \tfrac{1}{2}(8n - 16), \qquad (IV)$$

leading to the same values $n = 3$, $p = 4$. Pictorially the N_2O molecule is just like that of CO_2, the difference being that the several atoms which are similarly arranged are different atoms in the two cases. Both compounds are geometrically the same, however, and for this geometric identity of form we have a name—such substances are called isosters.

	CO_2	N_2O
Critical pressure (atmospheres)	77	75
Critical temperature, deg. Cent.	31.9	35.4
Heat conductivity at 100° Cent.	.0506	.0506
Density of liquid at 10° Cent.	.858	.856
Refractive index at 16° Cent.	1.190	1.193
Solubility in water at 0° Cent.	1.780	1.305
Solubility in alcohol at 15° Cent.	3.13	3.25

Because of the similarity in structure of isosters, we might infer that their physical properties are similar. That this inference would be strictly in accordance with the facts appears from the above table, the very marked correspondence here shown can hardly be accidental. It is quite evident that similarity of electronic structure carries with it a close identity of physical properties. This is of importance in checking up the determination of the physical con-

(Continued on page 606)

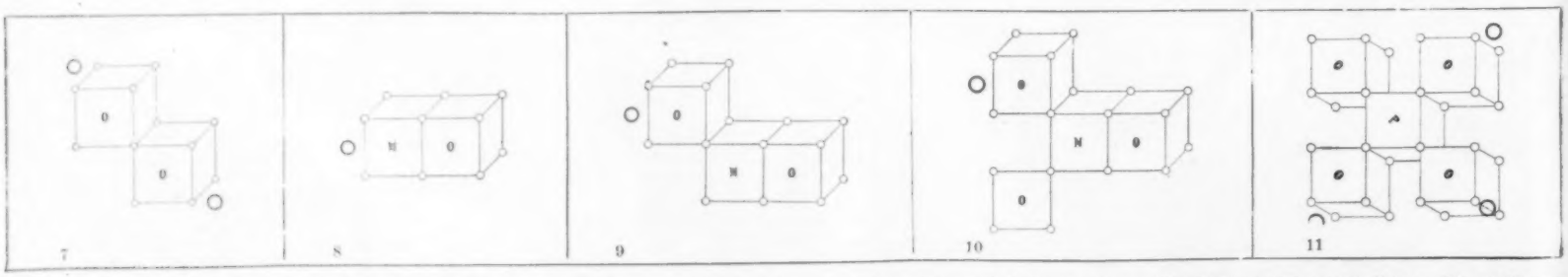


Fig. 7. Molecule of hydrogen peroxide, in which two octets use up fourteen electrons, six from each oxygen and one from each hydrogen atom. Fig. 8. Hyponitrous acid, HNO. Fig. 9. Nitrous acid, HNO_2. Fig. 10. Nitric Acid, HNO_3. With the addition of each oxygen atom, the molecule is rearranged so that the six fresh electrons may link up into an additional octet with those already present. Fig. 11. The rather complicated molecule of orthophosphoric acid, H_3PO_4. Here, as in the upper strip, the nucleus is shown only when, as in the case of a hydrogen atom, it does not fall within one of the octets.

Some molecules whose structure requires a little more ingenuity to reconcile them with the octet hypothesis

Correspondence

The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.

Farm Horse and Farm Tractor

To the Editor of the SCIENTIFIC AMERICAN:

In your article, "The Draft-Horse Situation," appearing under date of November 22nd, it seems to me that you have come to a questionable conclusion when you give, as the number of horses replaced by tractors on American farms, the horse-power of the total number of tractors sold. The power of tractors is of course not figured literally in terms of horses required to equal the tractor's output of work, but in terms of mechanical horse-power. The average farm horse produces more than a single horse-power, even over a period of protracted work, and in a pinch can produce very materially more than this amount.

B. M. PETTIT.

Akron, Ohio.

To the Editor of the SCIENTIFIC AMERICAN:

Several of our clients have written us concerning an article, "The Draft-Horse Situation," which appeared on page 510 of the SCIENTIFIC AMERICAN for November 22nd last. These men are affiliated with the horse industry and naturally are thoroughly familiar with the present economic status of the horse, and as well with the tractor situation in this country. Briefly, these men have expressed surprise and regret that the SCIENTIFIC AMERICAN should have published an article which they believe to contain statements that depart from the facts. We believe that it is of vital importance that our clients' side of the case be presented, and would appreciate any investigation which you may care to undertake that will throw light upon the accuracy of your article.

GREEN FULTON, CUNNINGHAM CO.

Detroit, Mich.

To the Editor of the SCIENTIFIC AMERICAN:

I assume that a publication with the standing yours possesses desires accuracy in the articles appearing therein. Statements appearing in your article, "The Draft-Horse Situation," are of such a character that it is evident this article was written by a man who is neither an engineer nor a horse man.

The outstanding blunder lies in assuming that a tractor developing 13 horse-power at the drawbar will displace 13 horses on the farm. Long experience, careful observation by agricultural engineers and accurate studies in surveys by the Department of Agriculture and by state agricultural colleges show conclusively that the average displacement of horses by a tractor on the farm is from 1.5 to 2.4 horses per tractor. Farms employing ten horses, after adding a tractor have been able to dispose of but three of these.

The second serious blunder is with regard to the number of tractors on farms in 1919. Reliable data drawn from the Department of Agriculture and other sources indicate that 200,000 tractors on farms is a very liberal estimate for the close of the working season of 1919. These would have displaced some 600,000 horses, instead of the ridiculous figure of 4,862,000. I hand you for your examination my copy of a survey of the horse situation made last year by the Green, Fulton, Cunningham Co. for the associated saddlery industries, the most complete statement of all phases of the matter ever published. This material is copyrighted by the Horse Association of America, which now holds all the original documents in the case; you have my permission to quote therefrom with proper credit.

WAYNE DINSMORE,
Secretary.

Chicago.

To the Editor of the SCIENTIFIC AMERICAN:

I have read with much interest the letters criticising my contribution, "The Draft-Horse Situation." I am sorry that the horse men are disgruntled and insist on pooh-poohing the inevitable.

As to the horse-power item, I made the most conservative estimates. The farm tractors in general use in California today are 40-60's and 75-90's, nominally. But of course that is not the net power at the drawbars. For the 40 the latter figure is about 16 horse-power; for the 75 about 37; for a new 60 just out it is 35. So you see my hypothetical ten-horse-power average for the United States is conservative in the extreme.

As to the extent to which the tractor lives up to its horse-power in running horses off the job, here is the written testimony of a practical California farmer. Mr. H. H. Bancroft of Walnut Creek says:

"When we bought our 40 tractor this spring we cancelled a contract for 18 horses and six men for the plowing and harrowing season. The purchase of the tracklayer made this big working organization unnecessary."

Now here is a 40-horse-power tractor that lays off 18 horses; and at the very most that you can get out of my original statement, it was not alleged to lay off more than 16. If you give my original statement a square deal it was not alleged to lay off more than 10 horses. So it would seem that my average of 10 horse-power and 10 horses is low; for I believe that the machine of which Mr. Bancroft's is representative comes close to the average now being used the country over.

Your correspondents are evidently in the horse business and very sensitive to the truth. But the idea advanced by one of them that a horse in a pinch will do more than a horse is the limit. I suppose the pinch comes when you pound the old horse over the back with a sledstake, holler your head off, and cuss a blue streak.

If I had made errors or near-errors in matters of alleged fact, I should feel more badly; but my propositions were advanced as purely speculative, with the idea of getting some basis of argument. Let us, however, look at some real figures. The farm horses of California fell off in number from 503,000 in 1914 to 435,000 in 1918. But the farm tractor did not really get into action until 1917; and the decrease from that year to the next was 33,000—nearly half the net loss for the entire four years. It is currently reported and believed here that the tractor will lay off not less than 43,000 more farm horses in California during 1920.

Another point which I would bring forward—the tractor hasn't really begun to show what it can do in this matter of displacing the horse. There are lots and lots of farms on which the tractor couldn't possibly displace its ten horses—because there are only two or three horses to be displaced. We haven't many of that sort out here, but you have a lot of them back in the East. Now it goes without saying that if the entire farming industry were to give up the horse and take up the tractor—the big tractor—these little fellows would cut down the batting average heavily. But—these little fellows haven't given up the horse, and won't till they get a tractor suited to their needs. Then there will be another big drop in the number of horses used on the farm.

H. A. CRAFTS.

Oakland, Cal.

The Editorial Judgment

We have examined the facts and theories advanced by Mr. Crafts in support of his article; we have examined the data put in our hands by Mr. Dinsmore; and we have conducted as thorough an independent investigation as we were able to undertake. As a result, we must emphatically repudiate Mr. Crafts' article, even though we print his defense. There is no question, we believe, that he has permitted his own observation of one or more extreme cases to blunt his ability to understand the significance of the term "average" and to comprehend the processes by which an average is derived. That there are farms in California and elsewhere where a big tractor can replace upwards of twenty horses everybody will admit. That Mr. Crafts is justified in his very light-hearted assumption that this is a representative performance for the entire country cannot be allowed.

Mr. Dinsmore presents figures for the United States as a whole which come from sufficiently reliable sources to stand as accurate. They tell us that where the United States in 1919 had about six per cent of the world's total population and seven per cent of its total land area, we had 23 per cent of the total supply of horses and mules. If anything this estimate is low because it gives 23,000,000 as the total of horses and mules in the United States, while the Department of Agriculture says there are 26,000,000. Of this total 86 per cent are localized on the farms. It is most significant that there are more horses in proportion to the improved acreage than ever before—one horse to 19 acres for 1919 as against one horse to 22.5 in 1870, to 23.5 in 1880, to 20.5 in 1890, to 19.3 in 1900, and to 19.8 in 1910. The survey which he mentions goes on to draw the following conclusions:

The tractor in its present state is a means of supplementary or auxiliary power rather than a substitute for the horse. It has made no appreciable dent in the number of horses on our farms. In at least fifty per cent of the cases as many horses are kept after its purchase as before. Of 600 county agents who answered a questionnaire on this and other points, 25 per cent said that the tractor had replaced the horse not at all, 60 per cent that it had done so to a very slight extent, 15 per cent that it had replaced less than five horses for each machine in use, while only three of these men estimated more than five horses replaced for each tractor. In no case are the horses displaced equal in value to the tractor. The horses remaining after the tractor has been installed continue to do in extreme cases as much as 95 per cent, plus, and as little as 40 per cent of all the work; on the average, they appear to do from 75 to 90 per cent of the work of the farm.

In spite of all this, the very definite consensus of opinion among the farmers and their representatives is that the tractor is a good investment. This is because the tractor makes it possible for them to do work which they never before undertook, and to operate on a larger scale. In other words, instead of replacing the horse, as a person without special information would naturally suppose that it must do in order to justify its existence, the tractor supplements the horse and extends the scope of the farmer's operations.

The findings of this survey are of course open to the charge of interestedness, and may therefore with propriety be checked against other sources of data. The Department of Agriculture constitutes such a source; and it agrees with the horse breeders in emphasizing the extent to which the tractor has not displaced the farm horse. Farmers' Bulletin, No. 963, "Tractor Experience in Illinois," speaks (page 26) as follows:

"Many men expect the purchase of a tractor to enable them to do away very largely with the use of horses for farm work. Up to the present time, however, the tractor has not displaced horses to the extent commonly expected. Its greatest advantage is that it does the heavy work quickly and thus completes it within the proper season." Substantially the same quotation appears in Farmers' Bulletin No. 1004, "The Gas Tractor in Eastern Farming," page 24; and in Farmers' Bulletin No. 1035, "The Farm Tractor in the Dakotas," page 29.

In each of these cases the bulletin goes on to estimate the number of horses replaced by the tractor in the area under discussion. For the eastern farm, "the tractor does displace horses to some extent, but only in about two-thirds of the cases where it is used on the same number of acres as were previously farmed. In these instances, the horses displaced average about two and one-half."

The eastern bulletin, of course, confesses that "New York farms, on account of the great diversification of crops raised"—and it might have added, on account also of the comparatively small size of these farms—"do not offer the most favorable conditions for the displacement of the horse by the tractor. Further light on this point is shed by the Illinois experience of Bulletin No. 963, which tells us that the corn belt, too, offers not the most favorable field for the replacement of the horse by the tractor. "The work which requires the largest amount of power on the corn-belt farm, contrary to a somewhat general opinion, is not plowing, but cultivating." The figure for horses replaced on farms which did not increase their acreage after the purchase of tractors was, for Illinois, four per tractor. The Dakota bulletin, covering a state where the tractor has every opportunity to make a showing, finds a figure slightly less than four, and in addition states that for a group of farms averaging 305 crop acres per farm, the number of acres cropped per horse before the purchase of the tractor was approximately 30, while since the machine was put on the job only one horse is kept for 46½ crop acres.

From all the data in the case the SCIENTIFIC AMERICAN is of the opinion that it is too early to attempt any estimate of what the tractor will ultimately do in the way of horse replacement. To date, however, it is certain that the tractor has not replaced the horse to an extent in any way comparable with the mechanical horse-power developed. Every authoritative discussion agrees with Mr. Dinsmore's survey that, so far, the chief accomplishment of the tractor has been to supplement the horse, to help out in the things which the horse does least well, and to extend the farmer's scope of operations; and that in doing these things it amply justifies its existence, without any question of whether it has put the farm horse out of business or ever will do so. We regret that our error in supposing Mr. Crafts to be in a position to speak authoritatively should have led to our publication of an article so open to question. We can only say in extenuation that there seemed every reason to believe that he was both in a position to know the facts and capable of dealing with them. From his previous record, in fact, we are convinced that it is only unconsciously that he has taken advantage of the fact that data and experience are to some extent conflicting to arrive at such questionable conclusions.

Ancient Remains in Colorado

The Mesa Verde National Park, Landmark of a Lost Race

By J. Walter Fewkes, Ph. D.

1. Southern end of Cliff Palace, showing Sun Temple across the canyon at the right. 2. Spruce-tree House, one of the few locations in the park where there has always been abundant water. 3. Sun Temple, as excavated by Dr. Fewkes; prior to his work it was a large mound covered with trees and bushes. The use to which it was put by its builders has not yet been entirely cleared up, but it certainly was not a dwelling place.

Some striking features of Mesa Verde National Park

View of the Sun Temple, in its present excavated condition, as seen when looking across Fewkes Canyon

IN the southwestern part of Colorado, not far from the Utah line, there lies a tableland which was named by early explorers the Mesa Verde. The name, meaning green plateau, it owes to the fact of its being covered with spruce and pine trees, imparting to it a green color.

On account of a growing interest in the protection of Indian antiquities this plateau was set aside by Congress as a National Park for the preservation of the aboriginal ruins scattered about in the rugged canyons which gash its surface. Although it had been known since 1875 that numerous caves of the Mancos River had been inhabited by a race of Indians called Cliff Dwellers, the greatest cliff houses of the Mesa Verde were not discovered until 1888 when two cowboys, searching for lost cattle, suddenly came upon remains of villages in the cliffs so large that it not only excited their curiosity but roused great interest throughout the country in the forgotten race that built them.

In the early legislation for the preservation of the aboriginal remains a liberal sum of money was allowed for developing roads by which one could more readily approach the plateau and travel about on its surface. Prior to that time the only way to scale the Mesa Verde was on horseback, following the old Indian trails and cow paths which had been used from time immemorial. An annual appropriation by Congress was devoted not only to the perfecting of the approaches but likewise to the employment of a superintendent and rangers who would care for the park and prevent a continuation of the despoliation of the ruins by pothunters who in the last years of the decade 1880-90 had committed sad havoc in many of the best ruins. A part of that appropriation, or about $1,500, was set aside in 1907 for the excavation and repair of the cliff dwellings on the park. This work was necessary not only for the prevention of further destruction due to erosion by the elements but was likewise desirable as a means of increasing their educational value to the large number of visitors whom it was foreseen would visit the Mesa as time went by. This work of excavation and repair was undertaken under the direction of the Bureau of American Ethnology in coöperation with the Department of the Interior. The first ruin treated is known as Spruce-tree House, a name given to it on account of a large spruce tree that grew out of one of the rooms in front of the buildings.

The canyon in which Spruce-tree House is situated is one of the few on the Mesa where there is abundant water; and it was a foregone conclusion that the neighborhood of this canyon would be the site of a camp ground or ultimately a hotel for the accommodation of those who would spend any time in inspecting the attractions of the park. In the early days a rude log cabin was constructed at that site, which later was followed by more pretentious accommodations.

Spruce-tree House was not only the first building repaired but it is typical of the one hundred or more found in the deserted canyons of the Mesa Verde. As it is the first one generally visited the tourist gets from this cliff house his first impression of these dwellings. It is therefore well not only to call it a typical ruin but also to describe in a little detail some of the more important features which are repeated in the others and characterize them all. The first fact to impress one is that this ruin completely fills the cave in which it lies. This cave is 216 feet long and from 30 to 50 feet high. The rooms in it are closely crowded together and are easily classified into two different kinds, one of which is round and subterranean, the other constructed above ground from floor to roof of the cave and rectangular in shape.

On examining the walls of the latter it may be noticed that there are evidences of three stories built one over the other. Each of these has openings indicating entrances, windows, and beams of the former floors projecting beyond the surface of the walls. In some of these rooms a floor is well preserved; in others it is broken, with nothing remaining but single rafters and beams. A street separating the rooms of the ruin into two sections extends from the front to a recess in the rear of the building, ending in a refuse heap or dumping place and cemetery. In this refuse heap have been found several dried-up human bodies wrapped in their burial robe, a peculiar

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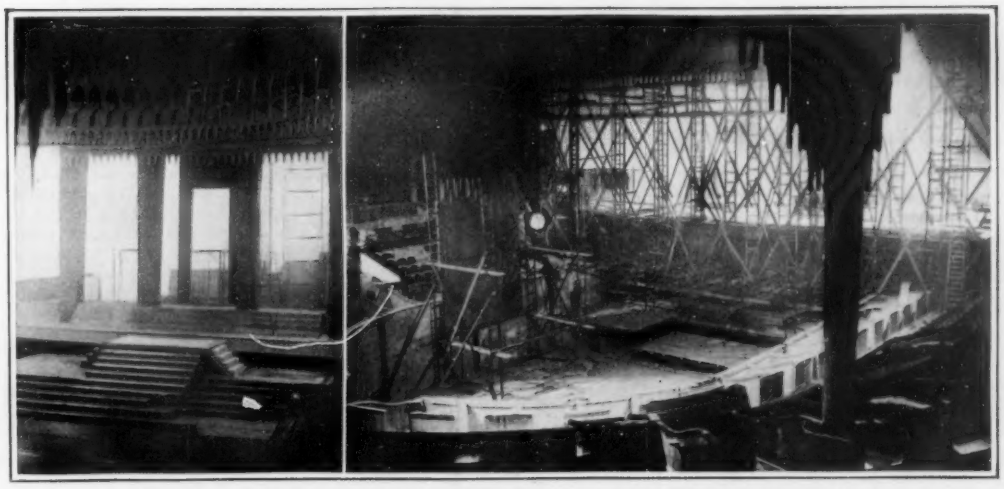
An Old Departure in Theater Building

By Dr. Alfred Gradenwitz



Two views of Berlin's new theater, showing how the audience surrounds the stage

AFTER an evolution of hundreds, nay, thousands of years, the theatrical art seems on the eve of partly reverting to its original forms. While keeping intact the results of an unceasing improvement and refinement of its means of expression, it seems about to add to these the sound fundamental principle lost in the course of the ages: the organic, intimate contact between the artist and his public.

In the classical theater of Greek and Roman antiquity, the actor would move about in an arena surrounded by the crowd of his fellow-citizens, throughout his performance feeling as one with those men and women whose impassionate interest in the play passing before their eyes could hardly have been keener if they had themselves been a party to the action. The theater of the Middle Ages in a similar manner had its stage on market-places and in streets and courts, and the public surrounding the players would feel and live with them. Even Shakespeare's and Molière's stages were not in front but, partly at least, in the midst of the auditorium, without any artificial barrier separating the artist from his public. It was left to the court-fashion of an even later period to place the stage like a peep-show in front of the spectator, who, from his seat far away from the scenery, would watch the play like the revelation of another world, to which he was a stranger. This isolation of the stage, truth to say, was attended by an unprecedented evolution of the art; in order to make himself understood to the spectators surrounding him, the actor had to refine his mimics to the very limits of possibility.

In the popular and open-air theaters there has lately been attempted something like a return to the origins of the theatrical art, to the time when players and spectators still were members of one social community. The spectators of the popular theater, the passion-play for instance, would feel as one with the actors recruited out of their own midst; the open-air theater tried to transfer the play into its actual scenery in the midst of nature. However, both afforded at most a partial solution of the problem, lending themselves only for certain, exceptional types of play.

A complete solution has been attempted by Max Reinhardt in his *Grosses Schauspielhaus*, just opened in Berlin. The motif of the new theater is to replace the hermetically closed flat peep-show stage by a space stage surrounding the spectator and forming with him an organic whole. Being freed from the fetters of the narrowly bounded traditional stage, the actor thus has unexpected means at his disposal freely to move about in space, feels more closely than ever connected with the public, a member himself of this public, whose intimate interest bears and enables him to develop his art more freely and more naturally than ever. His means of expression, truth to say, have to adapt themselves to meet the essentials of the changed surroundings, gestures and declamation rather than remaining, as heretofore, mere mimics, controlling the action.

The stage proper in the new Reinhardt theater only forms the decorative background; with its opening of 104 feet it considerably exceeds the stage of the Milan *Scala*, placed side by side with that of the Paris *Grand Opéra*. This background stage comprises a turntable and cupola horizon, and can be lifted to any level within a range of about 13 feet. The actual stage, however, is constituted by a fore-stage made up of 6 sections that can be raised and lowered independ-

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A theater of early Athens showing close contact between actors and public

A Racing Car with Two Engines

By Victor Pagé

OVER a decade ago Glenn Curtiss rode a special motorcycle at Daytona, Florida, and was reputed to be the first to make a mile at a speed of more than two miles per minute in a wheeled vehicle by covering the distance in 26 2/5 seconds. This record was made by using a freak machine built to test an eight-cylinder, air-cooled motor rated at 40 horsepower, that had been designed primarily for airplane work. Specially built steam cars have also covered the famous beach sand course at speeds approaching 120 miles per hour. The climax is capped when Tom Milton, driving a special freak car propelled by two engines, is credited with having broken all world's records for the mile and two-mile recently by covering the former distance in 23.07 seconds or at the rate of 156 miles per hour and the latter space in 46.24 seconds.

Naturally, to obtain this high speed, it is necessary to reduce the air resistance to as low a point as possible, which was done by stream-lining the car in just the same manner as an airplane fuselage is and for the same reason. All parts of the mechanism except the wire wheels are enclosed and even the disturbance in air flow that might be produced by the driver's head is taken care of in the same manner as in the fastest scout planes by using a small sloping windshield in front and a tapering aluminum head piece, well padded with an air cushion, back of the driver so the continuity of air flow is not disturbed by the projecting parts of the body.

While the streamline enclosure of the chassis is of interest because of the thoroughness with which it is carried out, it is not new; so the most interesting point and one that is a radical departure from usual racing car construction practice, is in the power plant installation. Reports are that the engines are eight cylinders each, the two combined making a sixteen-cylinder double-unit power plant. The engines are placed side by side at the front end of the chassis as is usual practice. The engines deliver their power to a special rear-axle construction, each engine having its own clutch and driving through flexible fabric universal joints and independent shafts to gearing in the rear axle. A very substantial tubular torque member to take the large drive reaction stresses extends from the center of the axle housing, between the driving shafts, to a suitable hinge anchorage on the frame cross-member just ahead of the front driving-joints. Each propeller shaft has a brake drum mounted at its rear end, a constricting band brake working on each drum. These are actuated by a pedal in the usual manner and provide unusually good control of the fast moving car.

No change-speed gearing appears to be used in this unusual racing vehicle nor is it needed because the car is much too powerful for street use and it is not difficult to "get away" by slipping the clutches when racing. Four carburetors are used, each one apparently serving

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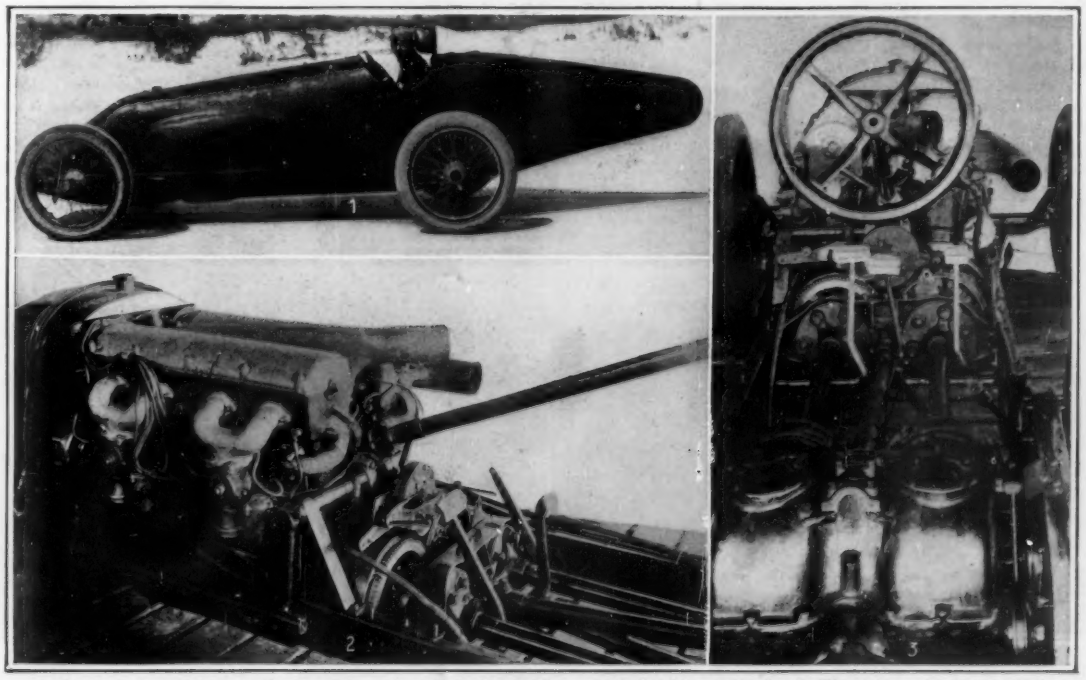

1. General view of the car, showing stream-line effect that applies even to the driver's head. 2. The twin-engine power plant. 3. Some details of the transmission system that couples the two engines to the axle.

Two engines to drive one car—the latest thing in racers

Solving the Short-Haul Problem

The Role of the Light, Narrow-Gage Railway in the Local Transportation of the Future

By Charles F. Lang

THE amazing use of the light railway by all the belligerents during the world war has very naturally given rise to the question as to whether this method of transportation has received in the past the attention which it deserves as a means for solving one of the most important phases of transportation, namely, a cheap method for the initial transport of agricultural products as well as certain minerals and other raw materials from the place of their origin either to some trunk line railway or to a nearby market. During the war many thousands of miles of light railways were built and used by all the warring powers on all fronts.

As is well known the trunk line railways furnished the backbone of support for the armies during the war. But transport had to be provided from the trunk line railway to the supports in the front line trenches. To accomplish this end, a variety of means of transportation had to be used—horses, mules, carts, wagons, automobile trucks, and last but not least, the light, narrow-gage military railway; this latter because it can be made available not only for use on or alongside the main highways which were also used by the horses and motor drawn vehicle but also because it could be laid in any direction through the fields so as to reach, by the most direct route, any desired point. By the liberal use of switches, these narrow-gage railways could radiate and extend in all directions from the main trunk line, radiating, fan-like, all over the country to be served.

On these railways much heavier loads were transported and in longer trains than ever had been considered possible before the war. This was largely due to the fact that the ties used were of a special oval channel form, nearly twice as heavy as the ties heretofore used on light railways; and, moreover, these ties were spaced only two feet from center to center of tie, and the channel dished formation wedging itself into the soil made the track more rigid than was possible in the more common commercial uses of light railways. The story of the light military railways will undoubtedly be written by some engineer historian, as it deserves to be, and the study of such a history should lead to a rapid development throughout the world.

The marvelous development of the standard-gage railway within the past century has opened up many hundreds of thousands of square miles of territory throughout the world, but in many countries as yet this development sticks close to the line of the railway itself.

Railways being even yet a new system of transportation, many mistakes have been made in the building of standard-gage railway lines through sections which could not support and maintain such railways. This has been especially true in the western part of the United States and even in some sections of the east, with the result that hundreds of miles of railways have been permanently unprofitable, and many have been totally abandoned; and as a result of the attention called to this fact by the unusual conditions growing out of the war the abandonment of many more is even now being seriously considered.

Another method of transportation which has existed from time immemorial, but which only recently has begun to have serious consideration on the Western Hemisphere, is the highway. The economic value of a well-built highway has been recognized in Europe since the time of the Romans, and it is astonishing that this system of transportation should have received so little consideration by the progressive peoples of South and North America.

THE existing railroads—with the possible conversion from steam to electric motive power—are doubtless adequate, in general principle, to conduct our long-distance transportation business for a long time to come. The finished highway of concrete or similar construction is feasible for comparatively rich and populous districts which can meet its first cost and supply enough traffic to make its maintenance worth while. But between these two types of transit, there is a vast gap which has never in the history of the world been adequately filled. Just what the gap has been and why it has existed, and how it seems likely to be permanently plugged up through one of the big lessons of the war, constitute the theme of Mr. Lang's story—and it is a story which he is eminently qualified to tell, since as an engineering executive he is in close touch with the development which he describes.—THE EDITOR.

I regret that I am not able to speak from knowledge regarding highway construction in South America, but in North America, both Canada and the United States, we have awakened to the necessity for well constructed and well maintained highways, and both countries have entered upon an enormous program for road construction which gives promise of exceeding in volume the rapid growth of railroad construction which followed the Civil War in the United States.

It is my belief, however, that neither the standard-gage railway nor the well constructed, paved highway will ever solve the transportation problem in countries of the Western Hemisphere. The highway will aid greatly in developing the sections of the country through which it passes, just as the standard railway has done, but the development will necessarily remain close to the highway. The highway will also do much toward relieving the short-haul problem to a nearby local market, this short-haul having always heretofore been one of the sources of loss to the standard railway.

It must be admitted, however, that highway construction, at least the paved, hard-surfaced highway, is so expensive to build of sufficient strength to stand up for years under the weight of traffic which passes over it that only fairly well settled communities can afford to make the investment. In other words, the highway will be largely built through communities already settled and developed for the purpose of taking care of the traffic which this developed territory creates.

We have then still before us the problem of some cheap method of transportation for sparsely settled or undeveloped stretches of territory, or for the purpose of connecting up large plantations or farms with their nearest markets or with their nearest trunk-line railway. This problem has received more attention in South America than in North American countries, and it is also being given serious consideration in such distant countries as the Philippines and South Africa where long stretches of country now have as their only means of transportation the ox-cart. These countries, confronted with the necessity for providing some better means of transportation, find it difficult to justify the building of expensive highways through long stretches of sparsely settled country, and yet must reach many points considerable distances from the few trunk-line railways in the country.

It is not my purpose within the very brief limits of this paper to go into the engineering problems involved, nor into the cost either of constructing or maintaining light railways, nor to compare such construction and maintenance costs with similar costs for standard-gage railways or paved highways. It is my intention and desire simply to outline briefly the possibilities of this method of transportation and its economy over the other two systems referred to.

The limitations of the standard-gage railway are so evident that it is unnec-

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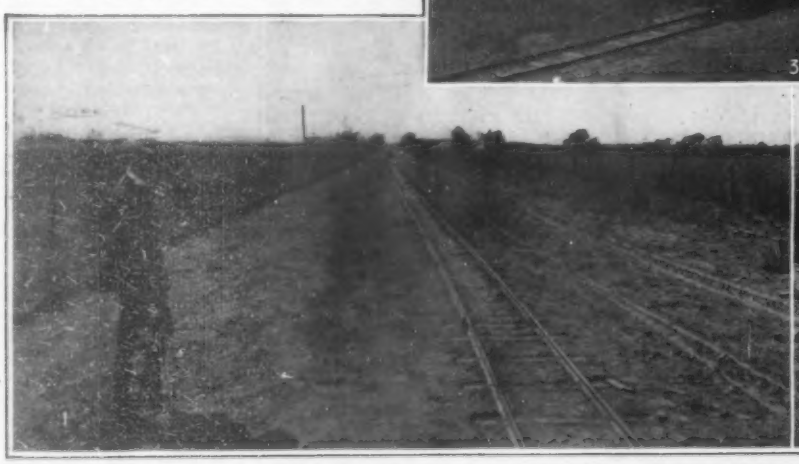
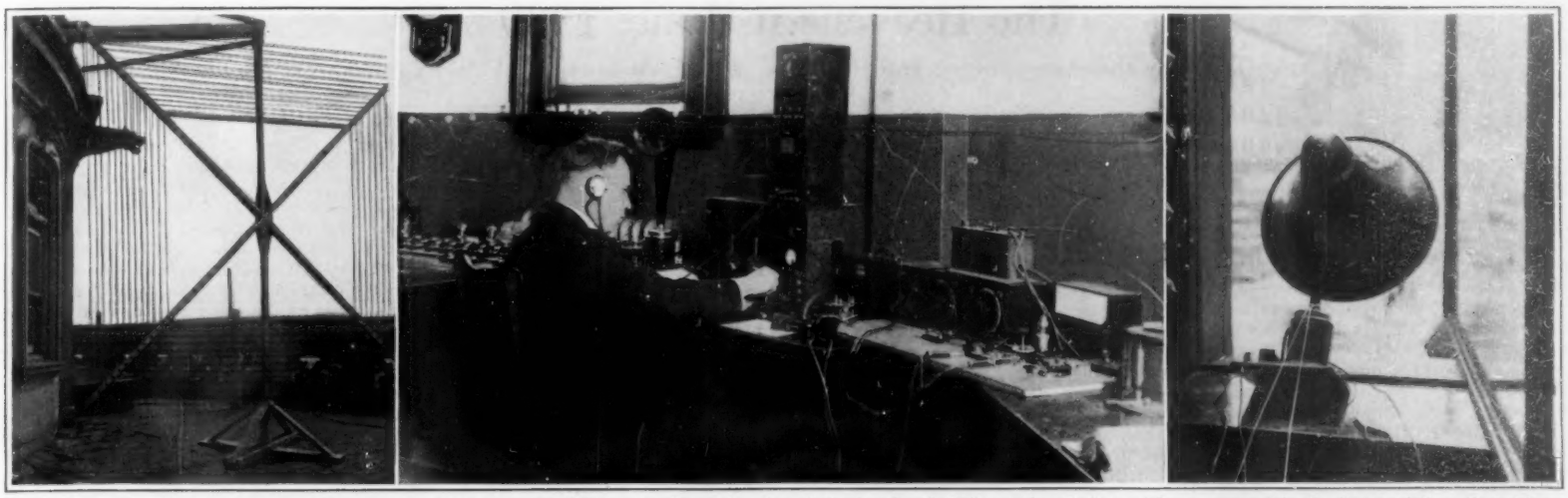


1. Light railroad of the sort outlined in the text in use in conjunction with an unimproved highway. When it comes time to pave the road, the tracks will enable this to be done at minimum cost.
2. A construction scene along the light railroad, showing the track sections with ties already bolted in place. These sections are moved successively off the forward ends of the cars, made fast in their places, and the train proceeds over them. 3. The scheme in operation; electric locomotive hauling a train of tiny hopper cars over the narrow-gage tracks.

The Lilliputian railroad which is suggested as a means for filling the gap that now exists between the service performed by the trunk line and that for which the highways are properly fitted



Three views of the wireless receiving station which permitted Secretary Daniels, aboard the battleship "Pennsylvania," to address a crowd in the heart of New York City

Speaking on a Battleship to a Crowd in New York City

ONLY recently we read in these columns of the remarkable work of Dr. Lee De Forest and how much the electrical world is indebted for his contributions. In fact, every day brings forth some new applications of the vacuum tube, the practical development of which is largely due to De Forest.

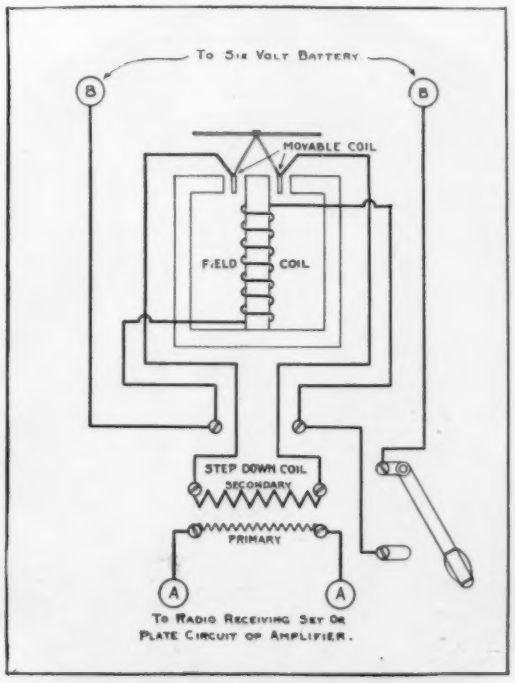
Again we are confronted with the remarkable possibilities of the vacuum tube, this time in the feat recently enacted in New York City, when Secretary Daniels, speaking aboard the battleship "Pennsylvania" anchored in the Hudson River, was heard by thousands of New Yorkers in Times Square—the heart of the city. Three-quarters of this feat was due to the application of the vacuum tube, and the remaining quarter to a very ingenious loud-speaking telephone apparatus which has of late found wide application in public speaking, announcing, radio telegraphy and telephony, and other fields.

For the purpose of the New York feat, a loop antenna, fourteen feet square, was mounted on the roof of the lofty Times Building as shown in the first of the accompanying views. A wire wound in square turns on a wooden framework, as here shown, forms a "loop" which takes the place of the usual antenna or aerial for receiving purposes. The "loop," which is mounted so as to be swung in any direction, is a real directional receiver. That is to say, it receives strong signals from any given station only when it is pointing edge on. Indeed, the "loop" is the basis of the radio compass, which now plays so big a part in navigation.

The station installed in the Times Building for the purpose of intercepting Mr. Daniels' voice emanating in the form of wireless waves from the "Pennsylvania," was of the standard Navy vacuum tube type, with several stages of amplification. Current from the final amplifier was led to the special loud-speaking telephone facing the populace, as shown in the third view.

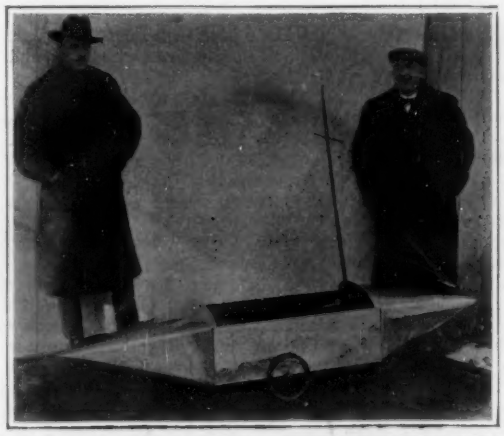
The new loud-speaking telephone apparatus is a development dating back to our entrance into the war. During the various Liberty Loan drives it was employed by public speakers for addressing large gatherings. In fact, this apparatus has several very obvious advantages over the loud-speaking telephone units placed overhead and covering a large area, one being in its extreme simplicity and in the point that it is instantly installed, and another that the voice or music comes from one definite source and is therefore more natural. In the case of numerous telephone units, one receives sound waves from all sides, and these sound waves by no means harmonize so there is apt to be considerable confusion at times.

Schematic details of the new loud-speaking telephone apparatus appear in the accompanying drawing. The electro-dynamic principle has been applied in this telephonic receiver. An iron-clad electromagnet is provided with a narrow circular air-gap in which exists a dense magnetic field. A circular-shaped, light, movable coil is suspended in this air-gap and is firmly attached to the diaphragm enclosed in the sound box. When the variable currents flow through the movable coil it will move in accordance with the characteristics of the incoming variable currents. The diaphragm, being firmly attached to the coil, will reproduce the signals. The construction of the electro-dynamic receiver permits the diaphragm to move as far as the natural resiliency of its material will permit, thereby giving the utmost strength to the sound waves generated. The receiving coil of the apparatus is wound so as to have a direct current resistance of 10 ohms. This necessitates the use of a special step-down coil or transformer as shown. The step-down coil is



Schematic arrangements of components and wiring of the electro-dynamic loud-speaking telephone

wound in sections to decrease the capacity effect of the coil. The primary winding, which is connected to the terminals *A A*, and from there connected to the radio receiving apparatus, is wound with about 1,500 ohms, direct current resistance, in nine sections.—By *Ralph Howard.*



The wireless hound—a radio-controlled vehicle which obeys its master's wireless commands

The Wireless Hound—An Interesting Case of Radio Control

TO be sure, there is nothing new about radio control. Ever since Marconi succeeded in getting a coherer to work by means of wireless waves, so that distant circuits might be controlled as desired, men in various countries have been planning and experimenting with radio-controlled craft of all kinds. During the war the Germans are said to have developed radio-controlled motor boats similar to those developed in this country by John Hays Hammond, Jr. And only recently we have learned of how Herr Fokker, the Dutchman who did so much to make Germany what she was in the air during the war, planned to produce thousands of small crewless airplanes controlled by radio for bomb-dropping purposes, while the United States was conducting experiments along the same line.

Now comes Edward F. Glavin of Yonkers, N. Y., with a radio-controlled vehicle which represents nine years of persistent effort and experimentation and numerous disappointments, all blended into the practical working model which is shown in the accompanying illustration. Mr. Glavin has succeeded in applying the principle of radio control to a land vehicle, which is considerably more difficult than that of aquatic craft.

The "wireless hound," as this bizarre vehicle has been termed by those who have seen it going through its antics, is driven by an electric motor. The vehicle has four wheels—one in front which does the steering, two wheels which turn freely on a fixed axle, and a center driving wheel. The electric motor is mounted on a pivoted frame in such a manner that its weight is brought to bear on its rubber-faced pulley pressing down on the driving wheel. Storage batteries furnish the current for the motor as well as for other purposes.

The control station consists of the usual tuned transmitter—a spark coil, telegraph key, oscillating circuit and aerial. Each time the key is depressed, a train of signals is sent out to the aerial of the wireless hound. Each train of signals causes the detector to respond, operating a relay and closing a secondary circuit in the conventional way. The secondary circuit makes use of a control or contact drum carrying various brass strips which, when turned, make various combinations of circuits in conjunction with the brushes or fingers pressing down on them. Thus in the first position the contact or control drum may make the necessary connections for starting the motor. The next position operates part of the electromagnets controlling the steering wheel, so as to turn the vehicle to the right, while the next position restores the steering wheel to the normal position and the vehicle straightens its course. The next two positions turn the vehicle to the left and straighten it out. Perhaps the next position stops the vehicle. At any rate that is the way the control operates.

Now as each train of waves is emitted by the control station, the contact drum of the vehicle is actuated by means of an electromagnetic dog-and-ratchet arrangement. Obviously, each position of the contact drum is fixed, so that if we are at position 3 and position 7 is the one required, it becomes necessary to go through all the intervening positions. However, this is readily accomplished by sending out as many wireless trains as may be necessary to arrive at the desired

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The Heavens in June, 1920

A New Tool for the Astronomer and Some of the Marvelous Work It Promises To Do

By Professor Henry Norris Russell, Ph.D.

THE recent meeting of the National Academy of Sciences at Washington was marked by one astronomical announcement of exceptional interest—the success of Professor Michelson in devising and putting into use an apparatus which permits the observation of double stars so close that their double character has never previously been detected.

It is well known to students of astronomy that the observation of close double stars is not a mere matter of magnifying power. The big lens or mirror of the telescope, to be sure, produces an image of the heavenly body toward which it is directed, and we can look at this image with different eyepieces, or magnifying glasses, thus securing different degrees of magnification. But there is a limit to this process set by the very nature of light itself. The waves of light, themselves so short that some fifty thousand go to an inch, pass through the opening of the telescope, a foot or more in diameter, with very little disturbance from its edges; but a minute effect nevertheless occurs, and the result is that the image of a star is not a mere point, as it ought almost to be geometrically, but a small bright disk surrounded by faint luminous rings. This system of disk and rings is exactly the same for all stars, and is purely an optical phenomenon, depending, not on anything about the stars under observation, but altogether on the size of the telescope employed. The bigger the clear aperture of the telescope the smaller is this diffraction pattern of disks and rings. Hence if the two components of a double star are close together, they cannot be seen separated with a small telescope, however perfectly it may be constructed, for the diffraction disks of the two stars overlap and form a single confused mass. With a larger telescope, these spurious star-disks are smaller and therefore appear separated.

With a 12-inch telescope, a pair of stars cannot be seen double unless their separation is 0".4 of arc. The corresponding limit, in seconds of arc, for other telescopes is inversely proportional to the aperture—thus a 60-inch telescope, under ideal conditions, should just resolve a double star separated by 0."08, and a 100-inch instrument one a little closer than 0."05. The least unsteadiness of the air, however, will spoil the "seeing" and make it impossible to utilize the full power of a large telescope. Except on unusually good nights the star images are enlarged and dance about irregularly, and often they are so much affected that all chance of observing fine detail is gone.

Two Stars Where Only One Appears

Even the theoretical resolving power of our greatest telescopes is however insufficient to separate many stars which are known from other evidence to be double. Many of the binary pairs revealed by the spectroscope are but a few millions of miles apart, so that their angular separation can at most be but a few thousandths of a second of arc. In other cases the probable separation is greater. For example, the bright star Capella is known to consist of two components of nearly equal brightness, revolving about one another in a period of 104 days at a distance which is at least half the earth's distance from the sun, and actually greater than this to a degree which depends upon the extent to which the orbit departs from being turned edgewise toward us.

From this fact, and from the measured parallax of the star, it can be shown that the angular separation of the components should be at least 0."03 or 0."04. Visual observations with the very greatest of telescopes have however uniformly failed to detect any duplicity, showing that it lies beyond their power, though probably only just beyond it. Professor Michelson has met this difficulty in a characteristic way—by an application of the very properties of light waves which block the direct road, coupled with the use of his own instrument, the interferometer.

Suppose that the light from a star is allowed to pass through two narrow parallel slits in the same plane, but an adjustable distance apart, and that this whole apparatus is put in front of the object glass of a telescope which brings these two beams of light to one focus. If the telescope is pointed exactly at the star, the light waves from the star will reach the two slits at exactly the same instant, and proceed through them toward the focal point. They will reach this point, too, at exactly the same time, and reinforce one another, producing a strong illumination. But if we take a point distant ever so little laterally from the focal point, on either side, the path of the rays from one slit will be longer than from the other, and the two trains of light waves on arriving at this second point will not be "in phase." If one is ahead of the other by one-half of a wave-length (or one-half of a vibration), the two will be in opposite phases, and will interfere or annul one another so that there will be no light at the corresponding point of the field. For a point twice as far from the starting point of our discussion, one beam will be a whole wave-length ahead of the other and the two will again reinforce, and so on. The result is that the field of view will be occupied by a series of fine bright lines or fringes, parallel to the slits and separated by dark spaces—a phenomenon which is familiar enough to readers of the SCIENTIFIC AMERICAN, since it has been described on these pages in connection with various developments of pure and industrial science.

At 11 o'clock: June 7.
At 10½ o'clock: June 14.
At 10 o'clock: June 22.

At 9 o'clock: July 7.
At 8½ o'clock: July 14.
At 8 o'clock: July 22.

At 9½ o'clock: June 30.

The hours given are in Standard Time. When local summer time is in effect, they must be made one hour later: 12 o'clock on June 7, etc.

NIGHT SKY: JUNE AND JULY

With a single star this is all that we shall see; but suppose that our star is double. The light of the second component will also produce a set of fringes. But if the light of the first star falls just squarely on the plane which contains the slits, that of the second star must fall upon it obliquely except at the moment when the second star is eclipsed by the first one. Though this obliquity is very slight, each light wave from the star affected will reach one slit a trifle before it reaches the other. It can easily be shown that this will displace the fringes in the focal plane of the telescope by an amount which is greater, the farther the slits are apart. If we start with the slits close together, the fringes produced by the light of the two stars will be superposed, and will intensify one another; but as we move the slits farther apart, one set of fringes will be displaced past the other, until the bright fringes of the one set fall on the dark intervals between those of the other set, and fill them up, producing a field of uniform brightness (provided, of course, the two components themselves are of substantially the same brightness). Knowing the distance between the slits when this happens, and the wave-length of the light, it is easy to calculate just how obliquely the rays of one of the component stars fall upon the slit plate when those of the other fall upon it perpendicularly, and from this the angle between the two rays of light—or between the two stars in the sky.

What We Shall Learn of the Double Stars

In all this description it has been tacitly assumed that the line joining the two stars (as they would be seen in the telescopic field if we had resolving power enough) is parallel to the line joining the centers of the slits, or perpendicular to the slits themselves. If the line joining the two stars is parallel to the two slits, the fringes will remain superposed, however widely the slits be separated. This may seem at first a difficulty, but it is really a great advantage. The whole slit-plate is mounted on the telescope so that it can be turned in its own plane through any desired angle. When the fringes are sharpest, the slits are parallel to the line joining the two stars; when they are set at right angles to this direction, the distance between them may be measured, as above.

It thus becomes possible to measure both the distance and the direction of the one star from the other. The theoretical resolving power of this apparatus is twice that of direct observation with the same telescope. What is even more important, it is found by experience that the atmospheric disturbances or "bad seeing," which are so troublesome in direct observation, affect the interferometer surprisingly little. The new instrument therefore makes it possible to measure double stars twice as close together as was previously possible with the same telescope, and to do this on nights when the seeing is so poor that under the older plan no such observations would ever have been attempted. The gain, both in precision and in efficiency, is extraordinary.

An apparatus working on this principle, though slightly different in detail, was set up under Professor Michelson's direction at Mount Wilson and turned upon Capella. The very first observations, on December 30th of last year, showed exactly such a change in the visibility of the fringes as had been predicted, thus fully confirming the duplicity of the star which had been proven by the spectroscope. The angular distance between the components was calculated to be 0."42, just too small to be resolved by direct vision in the greatest telescopes.

Later observations on Capella indicated a very rapid angular motion, amounting to four or five degrees per day; and by the middle of March the pair had been followed three-quarters of the way round their orbit. A diagram of the orbit, with numerical data, was exhibited by Professor Michelson at the meeting. Though the full details are not published, it may be mentioned that the maximum separation is about 0."05, and that the true distance of the components is very nearly 100,000,000 miles.

This is certainly a triumph for the new method at its very start. The future possibilities are great, alike in the study of telescopic double stars which at times get too close together to be seen with the existing instruments, in the discovery of new close pairs, and in the investigation of spectroscopic binaries. Professors Michelson and Hale plan the construction of an instrument working on the same principle, but without the intermediary of the great telescope, and in which the slits can be set still wider apart, permitting the measurement of even closer double stars. There is good reason to hope that, when this is perfected, it may even be possible to measure the angular diameters of a few of the brightest stars—using the same principle, but letting the light come from opposite sides of the

(Continued on page 611)

A single vast irrigated cotton field, of 26,000 acres, in which is grown a special, long-fiber cotton for automobile tires

Cotton for Automobile Tires

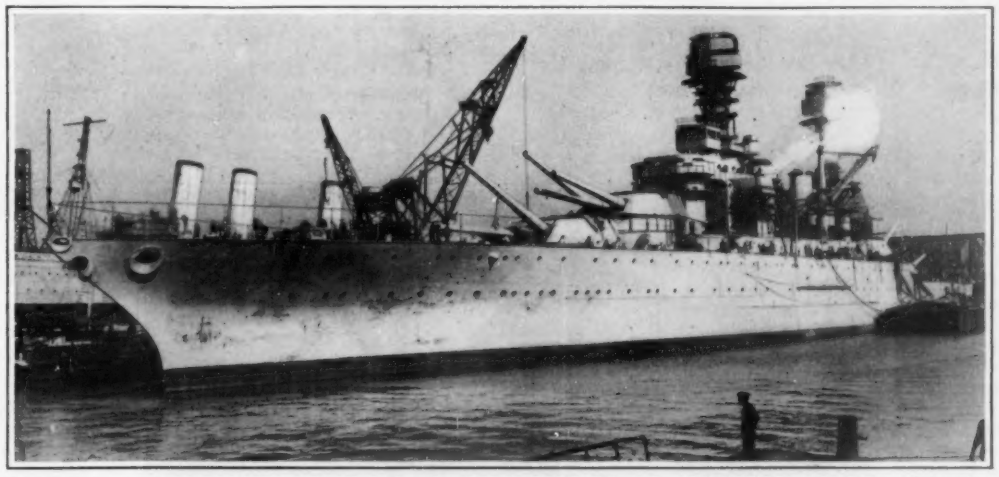
A SMALL gray insect, less than a quarter of an inch in length, brought to the United States an industry worth millions of dollars and gave employment to thousands of workers. If the boll-weevil had not visited the South Sea Islands in 1917 and destroyed a large part of the cotton crop, it is probable that the possibilities of this country for long-fiber cotton culture would not have been discovered for many years to come. The embargo placed by the British Government upon cotton imports from the Orient, although it hastened the attempt at the production of special long-fiber cotton in the United States, was not the primary inducement. Mainly to the boll-weevil, and to a less extent, to the exigencies of the war, we owe the fact that a cotton equal if not superior to that grown anywhere in the world is being produced in Arizona, where, in the Salt River Valley 28,000 acres of cream-colored bulbs now bloom with cotton fiber that averages one and eleven-sixteenth inches in length.

Cotton production in the Salt River Valley plantation has increased from 15,000 bales in 1917 to 37,000 bales last year. It is expected that the output in 1920 will be 50,000 bales, which will be about one-eighth of the total production to be used in the manufacture of automobile tires. Not everybody understands the association between cotton and automobile tires; yet cotton promises to remain indefinitely as indispensable an element in tire-making as is rubber. The average amount of cotton which goes to the making of a pneumatic tire is four pounds, and with the increased use of pneumatic truck tires, which require more material because of their larger size, the average will begin to run about five pounds to a tire.

Until 1910 none of the particular type of cotton desired for tire manufacture was grown in the United States. Then the Government agricultural scientists planted the brown Egyptian seed and the adaptability of this grade of cotton to the soil of certain regions of the United States became firmly established. The Pima and Yuma varieties have been developed from the original sakalarides Egyptian grade. These two kinds take their names from the location of their experimental growth, one being developed near the city of Yuma and the other on the Pima Indian reservation. Once it had been started the growth of the cotton raising industry in this district was assured. In 1912 Salt River Valley ranches raised 240 bales, which increased to 6,200 bales in 1914. Not much was raised for the next three years, but in 1916 some 3,400 bales were produced.

In 1917, because of the shortage of long staple cotton due to the above causes, the Goodyear Company undertook the development of a cotton plantation in the hope that the variable qualities of the open market might be overcome and the future supply of the company be assured. The development of two great cotton ranches was undertaken on a truly gigantic scale. More than 2,500 men and 1,100 mules were set to work making ready 6,000 acres of desert land which was cleared only after the hardest kind of labor. Planting was begun, and under the direction of the best cotton growing experts an efficient system of irrigation was built. The deep-well system of irrigation is used on both the Goodyear and Litchfield cotton ranches. These wells are from 150 to 300 feet deep, and the water is raised by electric power from the power station at the Roosevelt dam 84 miles distant. The total today under cultivation is 28,000 acres, and the water is distributed by 70 miles of ditches, of which 20 are cement lined. The irrigation is done from April to September. This irrigation requires great care, since over-irrigation will bring too much plant and too little cotton.

The success of the Salt River Valley venture has encouraged the company to develop cotton growing in the Imperial Valley of California, and to this end arrangements have been made for the selling of Egyptian cotton seed to ranches and for the purchase of a large portion of the crop of this valley.



Displacement: 32,600 tons. *Speed*: 21 knots. *Guns*: twelve 14"; fourteen 5". *Armor:* belt 14"; turrets 18" to 9"; conning tower 16".

U. S. S. Battleship "Tennessee" completing at the Brooklyn Yard

Completing the Battleship "Tennessee"

THE battleships "Tennessee" and "California," the former building at the New York Navy Yard and the latter at Mare Island, San Francisco, will be the last of our battleships to mount the fourteen-inch gun in their main batteries. With their completion we shall have eleven capital ships armed with this very effective weapon. Four, the "New York," "Texas," "Oklahoma" and "Nevada," carry 10 fourteen-inch guns; the "Pennsylvania," "Arizona," "Mississippi," "Idaho," "New Mexico," "California" and "Tennessee" carry twelve fourteen-inch guns, mounted in four three-gun turrets. The dimensions of the "Tennessee" are: length overall, 624 feet; beam, 97 feet 3½ inches; maximum draft, 31 feet, and speed, 21 knots. The ship is of truly handsome appearance with her long foredeck and clipper bow.

One of the most interesting features is the motive power, which is generally similar to that of "New Mexico." The current is supplied by two turbo-generators to four alternating current motors on four propeller shafts. This type of drive gives great flexibility in handling the ship, and possesses tactical advantages which have rendered it popular with the officers of our navy both ashore and afloat.

The armor plan is unusually heavy, calling for a fourteen-inch belt, eighteen inches to nine inches on the turret, fifteen inches to nine inches on the bases of the funnels, and sixteen inches on the conning tower. The protective deck is about three inches in thickness, and above that are other steel decks whose thickness varies according to the vitals of the ship which are to be protected. In addition to the twelve fourteen-inch guns, the "Tennessee" mounts fourteen five-inch and four three-inch anti-aircraft guns, and is provided with two twenty-one-inch submerged torpedo tubes.

Apart from the heavy battery and extensive armor protection of the ship, the "Tennessee" is remarkable for the completeness of her anti-torpedo protection, which consists of several longitudinal bulkheads, extending on each side of the ship between the outer shell plating and the longitudinal bulkheads enclosing the magazines and boiler and machinery spaces. This protection is intended to serve the same purpose as the bulge which is used on the British ships, for, like the bulge, it is extensively subdivided to localize the disruptive effects of the gases of a torpedo explosion.

The town and cotton ranch of Goodyear, Salt River Valley, Arizona

Inventions New and Interesting

A Department Devoted to Pioneer Work in the Arts

This concrete slab is being tested in the laboratory of the U. S. Bureau of Public Roads

The Strength of Concrete Slabs

WITHSTANDING a pressure of 119,000 pounds before ultimately collapsing, the slab described in the photograph was designed by the U. S. Bureau of Public Roads to ascertain the exact strength of reinforced concrete bridges when subjected to enormous loads. The bridge selected for the experiment was 32 feet wide, 16 feet in span length, with an effective depth of 6 inches.

The actual test was conducted by applying loads on this bridge through the medium of a hydraulic jack, extremely delicate measurements being taken by an instrument known as a strain gage. The device reflects the degree of compression of the concrete as well as indicates the extent of flexibility of the steel reinforcing steel bars under the tug of the load, such information being necessary in determining the efficiency of the slab under pressure and the apparatus finally being crushed under its maximum strength.

Many of the problems confronting the bridge engineer are necessarily consigned to laboratory tests for a solution. Both tests of materials and actual bridges, under experimental environments, are essential in revealing fundamental knowledge relative to the designing of bridges. Hence the series of investigations undertaken by the testing division of the U. S. Bureau of Public Roads in determining the strength of the reinforced concrete bridges that span our network of highways.—By *S. R. Winters.*

A safety razor blade, held in a suitable holder, makes an excellent ripping tool

New Type of British Airplane Engine

THE report comes from Manchester, England, that tests have been completed there by Capt. William P. Durtnall of a new type of airplane engine which will be silent, and from which the danger of fire in the air has been removed. The tests were made on a converted engine that had been previously operated on the Otto cycle system.

At present the exhaust pressure of the gases is very high in ordinary airplane engines, producing considerable noise. Under the system used in the Bowles and Durtnall engine, the exhaust gases leave the engine at ½-pound pressure per square inch, which results in "silent" operation. With so great a reduction of the temperature, it is claimed to be impossible to get a flame from the exhaust in any circumstances. The further claim is made that cheap heavy crude oil can be used in these engines, and that full power can be produced at altitudes up to 20,000 feet.

How the Inventor Is Helping Us Keep Clean

FROM Great Britain come the two ideas shown in the accompanying pair of illustrations. The first is a slot machine which has been widely installed by one of the English railroads in their coaches, in order that passengers might secure a clean towel on payment of one pence. The towels are held in trays and drop out of the machine after the fashion of exposed plates in a magazine camera. The second illustration shows a compact soap and towel set now being used by many English ladies who are in the habit of traveling a good part of their time. The set comprises a book of soap leaves, each leaf, when dissolved in water and rubbed between the hands, being sufficient for cleaning the hands of one person, as well as a number of paper towels. The entire set fits in a neat flat pocketbook which can be readily carried in the handbag or grip.

Slot machine for dispensing towels, and the soap leaves and paper towels of a new British toilet set

When the Safety Razor Blade Speeds Up Ripping

IF one of your safety razor blades seems dull, Mr. Husband, the good wife may be the guilty party. These blades make excellent knives for ripping. A recent perfection is a knife utilizing safety-razor blades for this very purpose. By unscrewing the handle of knife the blade is released and can be removed. It is small enough so that its presence in a workbasket does not interfere with other contents.—By *K. H. Hamilton.*

"Fish Scaling" in Enamels for Sheet Steel

AMONG the investigations being conducted by the Bureau of Standards, Department of Commerce, is that with a view to the elimination of "fish scaling" in enamels for sheet steel. A recent report says:

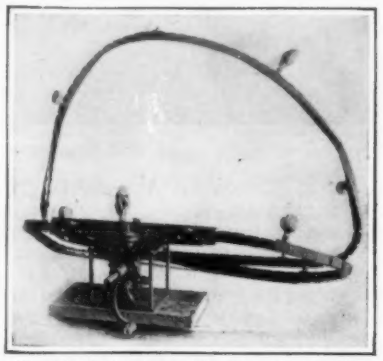
The jumping off of small particles of enamel, which results in the defect known in shop practice as "fish scaling," is probably the most serious defect to which enamels for sheet steel are subjected. It occurs intermittently in practically all the plants manufacturing this class of material in this country and entails losses running into millions of dollars to the manufacturers. At the request of the Metalware Manufacturers' Association of America, the Enameled Metal Division of the American Ceramic Society, and of a large number of individual manufacturers, the bureau is carrying on a comprehensive research in an endeavor to discover the cause or causes of this defect and the methods of controlling and eliminating it.

Up to the present time the bureau has made 90 melts of enamel comprised of 21 different compositions. These have been subjected to various treatments in firing and melting and have been applied in various ways to several kinds of steel. In all, over 4,000 sample enameled plates have been made up to date. This work has demonstrated that one of the most important factors in the production of fish scaling is too severe heat treatment in the firing of the enamel. Excess heat treatment may consist of firing the enamel at too high a temperature or of holding the enamel in the furnace for too long a time at a given temperature. Other important factors are the composition of the enamel, the physical and chemical characteristics of the underlying metal, the method of melting the chemical mixtures used in making the enamels, and the shape and weight of the pieces enameled.

Animated Lamps for the Window Display

AFTER all is said and done, the best window attraction or animated advertising display is something that moves—and that something attracts most attention when it is brilliantly illuminated.

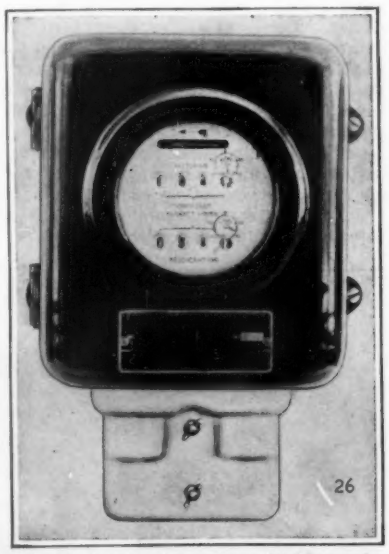
Working along these lines of proven advertising efficiency, Edward A. Dieterich of New York City, has invented a most novel system of window attraction. As will be noted in the accompanying illustration, this system consists of a number of incandescent lamps mounted on a wire-wound belt which travels through special U-shaped blocks forming a continuous channel, and a suitable driving mechanism for the belt. In this case the driving mechanism is simply a hand crank; but in regular commercial installations an electric motor would supply the motive power. The channel, being made up of numerous sections, is quite flexible, with the result that it can be twisted and bent into any desired shape, and accordingly the lights will travel through the same shapes and twists. The lamps get their current through the special wire-wound belt on which they are mounted, and are at all times brilliantly illuminated.



Electric lights travel in all sorts of twists and turns with this display device

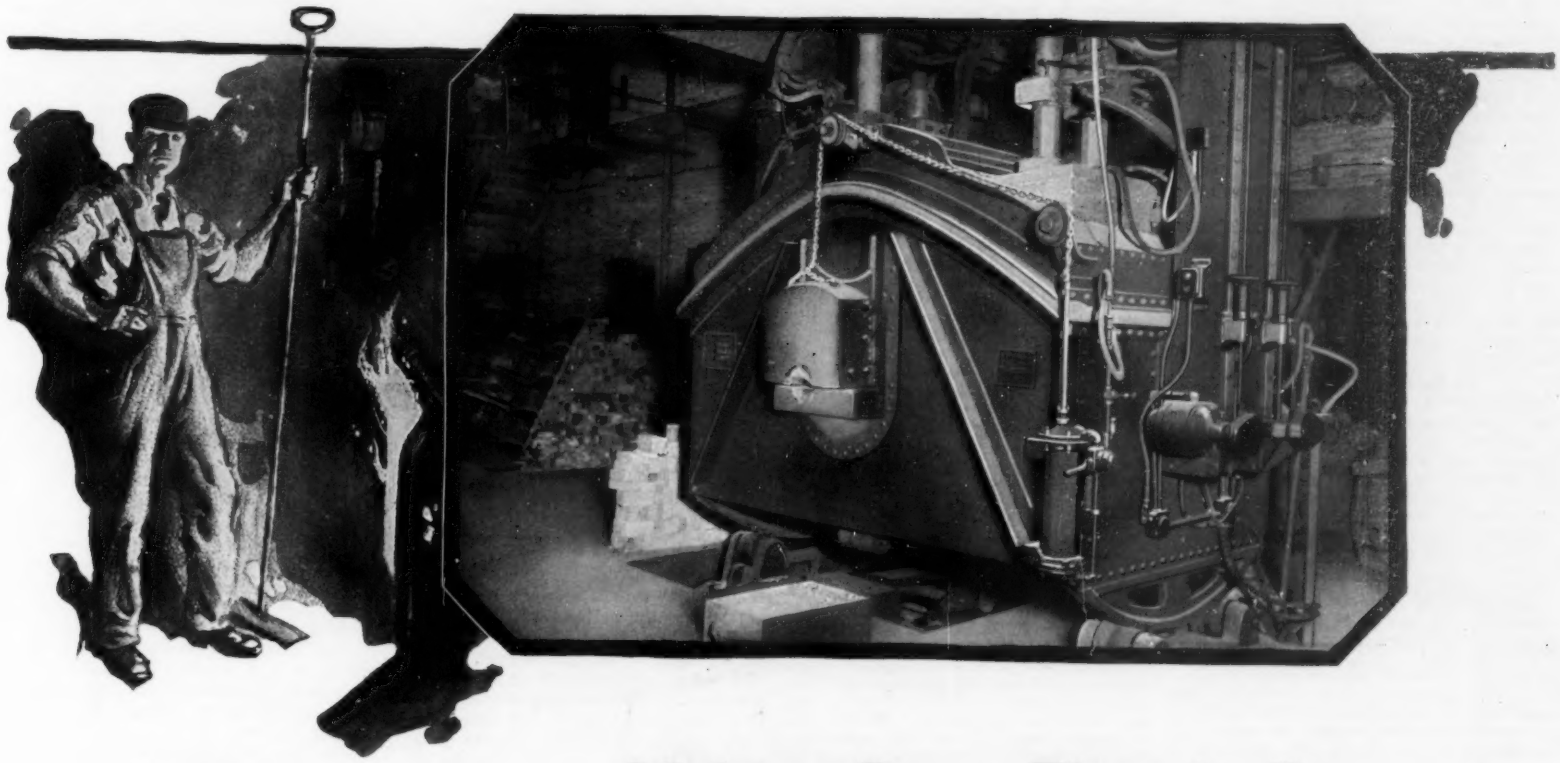
How Much Has Been Used and How Much Returned to Line?

HERE is a watt-hour meter that will accurately measure the energy consumed in driving the electric train, and the energy returned to the line through regenerative braking. It has two cyclometer type dials upon which these readings are shown. These meters are being installed on ten of the new electric locomotives of the Chicago, Milwaukee and St. Paul Railroad. Separate records of the motoring energy and the regenerated energy are shown, so that it will be necessary to take readings only at the beginning and end of the run. It is claimed that the results are exact instead of approximate as in previous practice.—By *G. Orb.*



Electric locomotive meter which records power consumed and power returned to line

The captains of industry have risen from the rank and file through sheer ability to recognize the modern way of doing the old job



Core baking oven

Electrically heated glue pot

Self-regulating solder pot

Melting Brass Electrically

LIKE a giant kettle, the electric furnace melts brass to a fluid with its clean intense heat, evenly distributed, perfectly controlled. Its use has revolutionized the alloying of metals, because electric heat can be brought to any temperature and kept there indefinitely. It eliminates the impurities caused by volatile matter and does away with costly reclamation of metal from slag. Electricity produces a "soaking" heat which penetrates every atom of the metals and combines them into a uniform mixture in a comparatively short time. It even permits the use of several temperatures in different parts of the same furnace, under automatic control, so that metallurgy, so important a factor in making metals for various purposes, has become more accurate, more precise, and therefore more dependable.

While the electric furnace is perhaps the greatest benefit to industry, it is only one phase of electric heat application. The electric oven that bakes cores quickly, thoroughly, and without loss by cracking or burning; the electric glue pot, melting pot, soldering iron, muffle furnace, sherardizing drum, japanning and enameling ovens — these are all proving invaluable in many broad fields of manufacture.

In electric heating, as in every other branch of its activities, the General Electric Company does not content itself with making one or two kinds of equipment. It covers the entire field, from largest to smallest device, so that any problem, however tiny or complex, may find a satisfactory solution in the hands of G-E engineers.

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Sales Offices in all large cities

39-37

Recently Patented Inventions

Brief Descriptions of Recently Patented Mechanical and Electrical Devices, Tools, Farming Implements, Etc.

Electrical Devices

ELECTRICAL CONDUCTOR.—H. GEORGE and J. HERBERT, Paris, France. The invention has for its object to provide an insulated and unalterable electrical conductor capable of being used for electrical purposes. The conductor consists essentially of a conducting wire of difficultly feasible substance inclosed in any insulating and non-porous material refractory to high temperatures. The conductor consists of a tungsten wire embedded in a mass of fused quartz.

INSULATOR CLAMP.—J. SCHNEIDER, 441 E. Jersey St., Elizabeth, N. J. An object of the invention is to provide the design of an insulator clamp which may be clamped upon the head of the standard and conventional type of insulators or high tension electrical transmission lines. A particular object is to provide an insulator clamp which will in effect function as an adapter to be mounted upon the uppermost head of an insulator for the purpose of holding in position electrical transmission conductors or wires carried by the insulator.

Of Interest to Farmers

CULTIVATOR.—G. W. HAMMOND, Morocco, Ind. The primary object of the invention is to provide a so-called sulky cultivator which is capable of simultaneously cultivating the soil between a number of rows of vegetables. A further object is to so construct the cultivator that the blades thereof may be vertically and horizontally adjusted relative to the soil over which they are drawn.

Of General Interest

ADJUSTABLE FOOTREST FOR HIGH CHAIRS.—E. E. and E. B. MCCLARY, 117 No. Broadway, Pittsburgh, Kan. This invention relates to children's high chairs and has for an object to provide an attachment wherein a proper adjustment may be secured to conform with the child's age. Another object is to provide a foot rest wherein the parts may be adjusted to act at one time as merely a rest for the feet and at another time as a safety device for preventing the child from slipping out of the chair.

PHOTOGRAPHIC RECORDER. — W. C. DUBYEA, Princeton, N. J. The invention has particular reference to means for easily, accurately and expeditiously forming upon strips or films any desired phenomena, such as vibrations due to sound waves or the like. Among the objects is to provide a photographic recorder having among others the following functions: A recording chronograph to register the movements of an oscillograph; a moving coil galvanometer, for use in examining or studying the pulsations of the heart through the instrumentality of an electro-cardiograph; and also for recording telegraphic, cable, or wireless messages, signals or the like.

Hardware and Tools

WRENCH.—H. L. OSMENT, c/o Nixon Hardware Co., Rome, Ga. The invention has for an object the provision of a construction of wrench of the general type of monkey wrench with a raised portion or cam for causing a gripping of the jaws on various shaped objects when power is applied. Another object is the provision of a handle having an adjustable jaw formed with a ratch bar having the smooth edge fitting against the rounded cam portion whereby one jaw may rock in respect to the other during the gripping action.

LOCK.—L. H. GOROWITZ, 227 E. 119th St., New York, N. Y. The invention relates more particularly to a door lock having double security or locking means, whereby the lock may be actuated from the inside or from the outside; and it is a further object to provide a lock which will effectually lock a door against passage of a person there through from the inside to the outside after the door has been locked on the outside thereof. It is a further object to provide means to prevent the use of a chisel or other tool to prize the lock parts open.

Heating and Lighting

WATER GLASS LIGHT.—T. KENNEDY and C. E. KISER, 804 Ave. A, Newton, Kan. The object of the invention is to provide a light adapted to be arranged behind a water glass and to be connected with the back plate of the guard for the glass, wherein the lamp is enclosed in a metal sheath having means for attaching it to the back plate, the back plate having a slot through which the light may illuminate the glass and the water.

Machines and Mechanical Devices

UNLOADING MECHANISM.—R. H. ALDRICH, Allentown, Pa. The invention relates to pumps; its object is to provide an unloading mechanism arranged to unload the pumps by preventing it from pumping water or other fluid to an accumulator or other device as soon as the fluid pumped into the accumulator reaches its maximum. Another object is to cause the pump to pump fluid into the accumulator as soon as the fluid therein drops to a predetermined amount.

Medical Devices

FOOT PRESSURE REFLECTOR. — A. SMITH, JR., 2009 7th Ave., New York, N. Y. The invention relates generally to surgical appliances, and more particularly to a device adapted for use by pediatrists, chiropodists, and orthopedic doctors in examining foot ailments such as Morton toe, weak and flat feet, and to enable them to make a proper diagnosis.

Musical Devices

DIAPHRAGM.—P. E. BUTOW, 163 13th St., Brooklyn, N. Y. The invention has particular reference to the construction of the sound boxes or reproducers of sound-recording machines. Among the objects is to provide a construction of the diaphragm whereby it is expedient to record and reproduce the tones of the human voice or other familiar sounds in the most faithful manner.

Prime Movers and Their Accessories

IGNITION MAGNETO FOR INTERNAL COMBUSTION ENGINES.—E. MALIVERT, 17 Rue du Pre-Saint-Gervais, Paris, France. The patentee provides in an ignition magneto pole pieces associated with the armature, and movable pole pieces in a novel relation to each other and to the pole pieces of the armature, the purpose being to overcome certain disadvantages incident to the usual construction and operation of high tension magnetos in regulating the ignition spark.

Pertaining to Recreation

PLEASURE MACHINE.—H. WILKENS, 620 34th St., Norfolk, Pa. The invention relates to amusement devices such as are commonly operated at seaside or other amusement resorts. More especially the invention comprises a frame structure rotatable around a vertical axis and within and above a stationary annular trackway and having associated with the rotatable frame a number of carriers for passengers movably supported upon the trackway and caused to be actuated thereover by means that causes the rotation of the frame work.

Designs

DESIGN FOR A POWDER CONTAINER OR SIMILAR RECEPTACLE.—C. S. HUMPHREY, c/o Manhattan Can Co., Bush Terminal No. 10, Brooklyn N. Y.

DESIGN FOR A CAP FOR A POWDER CONTAINER.—C. S. HUMPHREY, c/o Manhattan Can Co., Bush Terminal No. 10, Brooklyn, N. Y.

DESIGN FOR AN ARTICLE OF MANUFACTURE.—E. M. LOFTUS, c/o Warner Mfg. Co., 23 E. 22nd St., New York, N. Y.

We wish to call attention to the fact that we are in a position to render competent services in every branch of patent or trade-mark work. Our staff is composed of mechanical, electrical and chemical experts, thoroughly trained to prepare and prosecute all patent applications, irrespective of the complex nature of the subject-matter involved, or of the specialized, technical or scientific knowledge required therefor.

We also have associates throughout the world, who assist in the prosecution of patent and trade-mark applications filed in all countries foreign to the United States.

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The Overhead Cable Crossing

(Continued from page 594)

The original plan contemplated using the main steel cables as transmission lines and effecting their insulation from the towers by means of specially designed insulators. However, the insulators were not ready in time; so that it was decided to use the steel cables as messenger lines. That is, the steel ropes serve as a means of suspension for stranded copper conductors. At intervals of 250 feet, the copper lines are supported by suspension insulators having eight units in a string. This feature is a departure from the first conception but it has proved so successful that it will probably lead to a further modification of original plans.

Part of the submarine crossing was to be maintained as a standby until such time as a second, a duplicate, overhead crossing should be constructed. Those in control have concluded that their experience demonstrates the feasibility of using the present crossing for two circuits. If this scheme can be carried out successfully, a great deal of expense will be saved. Two alternatives are in view. In accordance with one, the steel cables would be in one circuit and the copper lines in the other. The alternative provides for carrying two copper conductors on each steel rope. To carry out the second plan, light triangular frames of steel or aluminum would be attached to the steel cables at intervals of 200-500 feet, and the copper lines carried by suspension from the ends of the frames. The steel cables now installed are built up on a stranded core of 30 wires. The enveloping strands are six in number and each contains 19 wires. Plow steel, galvanized, is the material.

The cables normally clear the river during high water by 175 feet. The entire weight of each cable is nearly 30,000 pounds. It will readily be understood that the piers on which the towers stand have very considerable weights to support, the towers themselves being quite heavy without the addition of steel and copper lines. Consequently, the foundations had to be provided for with care and thoroughness. Preliminary bore holes put down to a depth of 100 feet showed nothing but a very fine white sand with an occasional stratum consisting of sand mixed with clay. It was judged difficult to use piles satisfactorily in this material for foundation purposes; and objections were entertained as to the possibility of a sure mat foundation. These systems excluded, the choice fell upon open caisson piers.

An orange-peel excavating bucket dug the material from the inside and thus let the growing weight settle down lower and lower through the sand until a penetration of 40 feet had been attained. Rich concrete was poured to fill the tapered bottom of the hole, and ordinary concrete to fill the main portion. This foundation work was carried out with less difficulty on the north side of the river. On the south side, numerous boulders, some of them too large for the bucket, were encountered. The blasting of the big fellows required the unwatering of the caissons as a preliminary to drilling the blast holes and charging them. The total load each group of four piers had to support was estimated at 530,000 pounds. Of this total, 350,000 pounds belongs to the tower itself, while 180,000 pounds is the downward thrust due to the cables.

The Canadian winds at times blow with a strong urge, and this is naturally true of the Laurentian Valley as of other sections. It was estimated that the towers would have to be capable of withstanding a horizontal thrust by the wind amounting to 400 pounds per foot of height. The stress on the cables due to wind would produce, it was calculated, a horizontal thrust at the top of the tower perpendicular to the line amounting to 26,000 pounds. The pull of the line parallel to itself would stress the top 42,000 pounds. Taking everything into consideration, the engineers calculated that the maximum compression on each front leg would be 575,000 pounds, and the maximum uplift on each rear leg, 233,000 pounds. Under maximum load the towers do not remain absolutely vertical, the calculated deflection being 4½ inches.

The Architecture of the Molecule

(Continued from page 596)

stants, and even more so in predicting the properties of unknown compounds or those which have not been subjected to determination. Examples could be multiplied, but this seems hardly necessary.

Another application of the theory enables one to ascertain whether or not certain chemical compounds can exist. Let us, for instance, investigate the hypothetical hydrocarbon CH_6. Here we have four available electrons from the single carbon atom, and six from the six hydrogen atoms—ten in all. Since it takes at least twelve electrons to make two octets, n here may only be 1, and with $e = 10$ as just seen we have:

$$p = \tfrac{1}{2}\ (8 - 10),$$

whence $p = 1$ and the proposed compound cannot exist. Of course this particular example makes no contribution of new knowledge, since on grounds of valence the proposed substance could not exist, hydrogen being univalent and carbon at most quadrivalent. But more elaborate examples might demonstrate the nonexistence of compounds which on other grounds could not be ruled out; while even in the case chosen for demonstration, the present theory and method seem to go a little farther back toward ultimate causes than the bald assertion that a single carbon atom cannot hold on to more than four atoms of hydrogen.

A more elaborate extension of this technique is found to account for the phenomena of isomerism. The theory also harmonizes with the known facts of stereoisomerism.

A few other examples of the working of the theory are shown in our illustrations. The molecule of water is shown with the hydrogen nuclei, each of which has supplied a single electron to complete the octet of which the six available electrons from the oxygen atom form the foundation. The molecule of hydrogen peroxide, of course, has fourteen available electrons grouped into two octets. Other diagrams are self-explanatory.

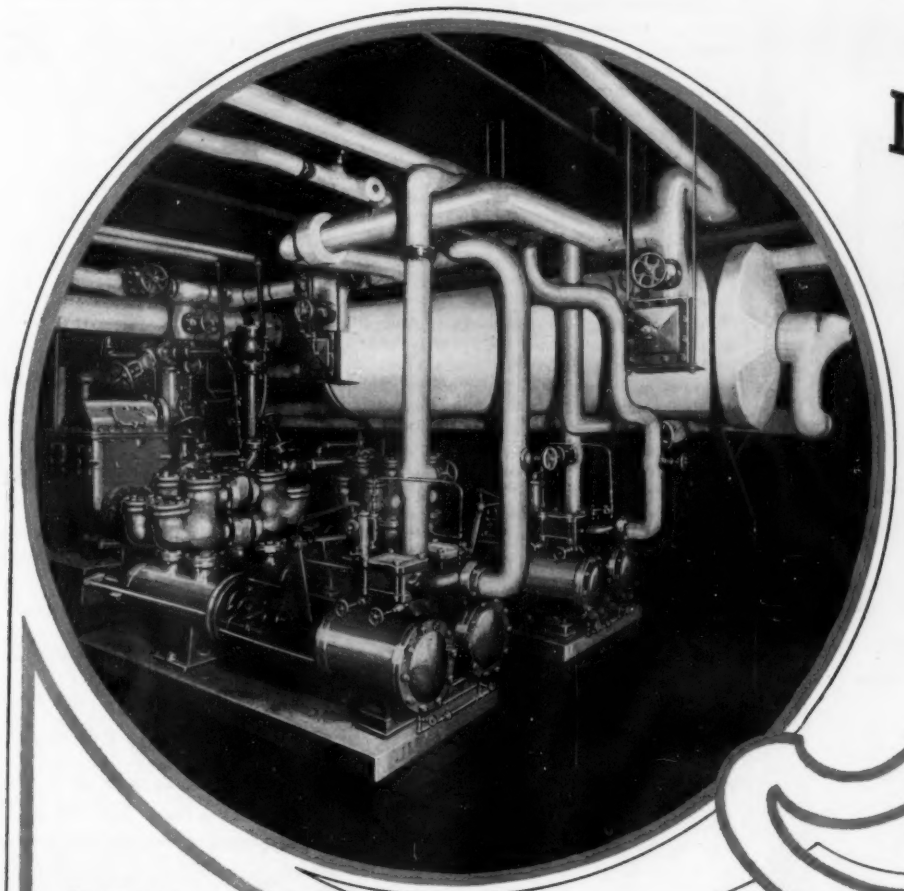
The elaboration and further application of this theory will undoubtedly extend our horizon in the twin sciences of physics and chemistry. As a working hypothesis it gives promise of much technical usefulness, especially in the field of research. Those who are interested in further details than it has been possible to give in these pages are referred to the *Journal of the American Chemical Society*, Vol. XLI, Nos. 6, 10, Vol. XLII, No. 2; to the *General Electric Review*, Vol. XXII, Nos. 7, 8, 9, and to *Chemical and Metallurgical Engineering*, Vol. XXI, No. 2.

Ancient Remains in Colorado

(Continued from page 598)

cloth made of fiber of the yucca in which were woven feathers of the eagle and turkey. These human remains are not mummies like those of Egypt, but simply human bodies which had dried up, owing to the fact that no moisture had penetrated into the depths of the caves since they were buried. This was not, however, the only place where burials occurred, for in the floor of one of the rooms was found the body of a man who appeared to be a priest, surrounded by the insignia of his sacerdotal office. In other rooms were the mills on which the maids formerly ground the corn, still standing in the places where they were left when the

(Continued on page 608)



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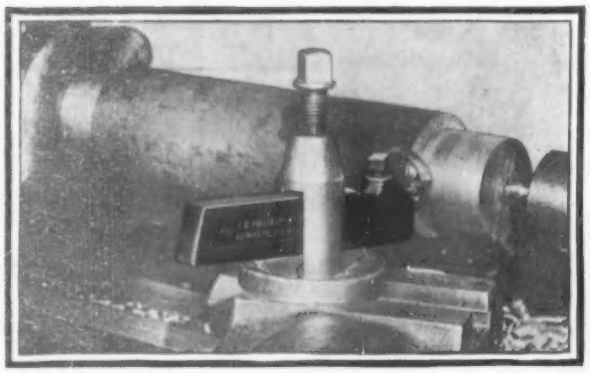

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Ancient Remains in Colorado

(*Continued from page 606*)

dwelling was abandoned, and not far away were corncobs and other food remains associated with pots that had been used in cooking their food, and the ovens with smoke adhering to the walls. There were also found various types of stone implements; in fact all kinds of utensils and implements illustrating the secular life of the people who had disappeared were found where they were left by the ancient inhabitants. The evidences of artistic feeling should not be overlooked, for on the walls of the rooms were traces of pictures or figures used in their decoration. These walls had been nicely plastered with mud by human hands, the imprints of which were still to be seen, and painted white above and red below, with rude figures of butterflies and birds.

About two miles and a half from Spruce-tree House is situated the largest cliff house in the United States, known as Cliff Palace. This fanciful name was given it by its discoverers in 1888, but of course the building never was a palace in the ordinary acceptation of the term. It was a community dwelling composed of many rooms inhabited by numerous clans or families, so united that they practically cover the whole floor of the cave, the roof of which towers high above. In the earliest settlement when the first colonists sought this cave for their homes we may well believe that their number was small and families limited in size. These families were governed by what is called the mother right—that is, the ownership of the house was vested in the clan which the oldest woman controlled. When her daughters, if she had any, were married their husbands who were of a different clan came to the house of the mother-in-law to live and rooms for the accommodation of the new family were built near the maternal dwelling. It thus happens that the original clan dwelling became a nucleus of the future pueblo which was augmented in size as time went on by new families which united with those already living there. When these families domiciled in the cave increased in size by the birth of children, the whole cave floor in the course of time was covered with dwellings united, and available sites for new buildings were exhausted. At such a time there was only one thing to do as the population increased, and that was to erect houses on the roofs of those already existing; the cliff dwellers were obliged to construct story after story, one above another, in order to be protected by the cave roof. Naturally these superposed rooms could be entered only by balconies or by adopting a terraced arrangement. There is every probability that each clan or social unit like a family is now indicated by the circular subterranean room or council chamber, and that the population of Cliff Palace may be estimated from their number. There are 23 of these units in Cliff Palace, and allowing 20 people for each clan the population would be about 600 people.

As we look across the deep canyon west of Cliff Palace an extraordinary structure is visible on top of a great promontory that forms its rim. This mysterious building is not a cliff house, but is unique among the ancient buildings in North America. From a distance it resembles a huge tower, but on nearer examination is found to have a D-shaped form of finest masonry 131 feet in length with walls in places rising 12 feet high. In the spring of 1915 the site of this building was occupied by a mound of stone and earth overgrown with a thick underbrush, out of which rose several pine and cedar trees, one of which was especially conspicuous. A superficial examination of the surface of this mound showed the existence of many cubical stones well fashioned and dressed by human hands, showing the markings of pecking stone

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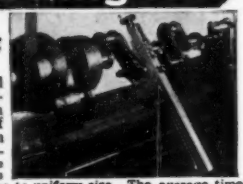

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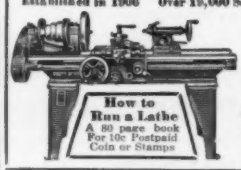

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over their surface. Three months' work on this mound revealed the building now widely known as Sun Temple, the most mysterious on the Mesa Verde Park.

Many theories have been suggested as to the purpose of this remarkable structure which still remains after four years as enigmatical as when its walls rose out of the mound. There are no evidences that it was built for a habitation, as no domestic objects were found in its rooms. Its shape and fine masonry would not be expected in a fortification although it may have been a sanctuary or for storage of corn or other food. The resemblances of the enclosed circular rooms to ceremonial chambers, but more especially the existence of a shrine suggesting the sun on the corner stone of the southwest angle, led to the supposition that the building was a temple erected for solar worship, combining with its religious use a sanctuary for protection with accompanying rooms for storage for food. The use of Sun Temple is more or less of a mystery, and on that account remains a most attractive building to visitors to the Mesa Verde National Park.

Three questions are naturally asked by every one who considers the many ruined buildings on the Mesa Verde. First, Who were the builders, or to what race of people were they most closely related? There is not a shadow of doubt that they were Indians. Neither can it be assumed that when their ancestors came to the Mesa Verde or the adjoining plain they were familiar with the mason's craft; consequently we may suppose that in those early days they were not very different in manners and customs from the Utes or Navajo who still live in earth lodges or temporary structures constructed of earth and logs. The true relation of the ancestry of the people can be better known after more investigation, or when the structure of the simplest forms of these buildings is more carefully studied.

How old are these buildings, is another fundamental question which is asked by every visitor. This is equally difficult to answer. We cannot assign their age in terms of the Christian era, but there is no conclusive evidence that they are more than five or six centuries old. Their age certainly can be compared with the venerable ruins in the Old World. Means of demonstrating their age are absent, but it may be interesting to know that on top of the highest wall of Sun Temple there can still be seen the stump of a tree with 360 annual rings of growth which germinated after the top of walls that form the mound had fallen.

What became of the people who inhabited and built the Mesa Verde cliff dwellings? Why did they leave their well made habitations and other buildings constructed with so much care? These questions, like the two preceding, cannot at present be answered satisfactorily. We only know that the civilization they represent had reached its apex before the coming of the white man and, declining, these farms and populous villages were deserted. Their descendants, if any, must be sought elsewhere: the Utes who claimed Mesa Verde as their land when the white man came have no story to tell regarding the fate of their predecessors. Whatever survivors are still extant must be sought for many miles from their ancient home, among the modern Pueblos. These no longer erect buildings comparable in masonry with the cliff houses, but of mud, clay, or sticks, or even unshaped stones. These Pueblo people still tell legends or stories of the olden time when their ancestors lived in the north, but these are very indefinite and afford us little aid in deciphering the culture and the fate of the Mesa Verde people. In the course of time as renewed investigations of many other ruins which lie between the Mesa Verde and the villages inhabited by their modern survivors have progressed we may be able to resurrect from the

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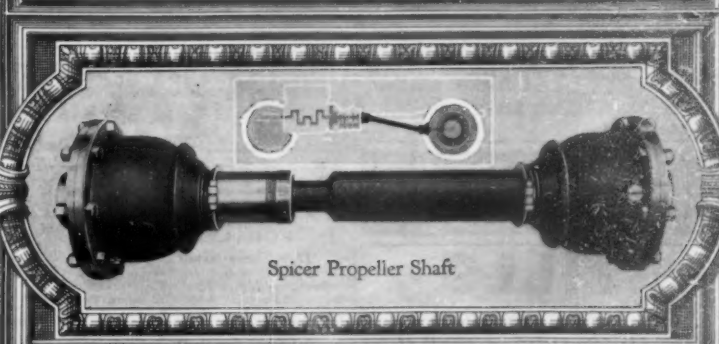

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archaeological material now buried in the earth traces of ancient migrations or ancient kinship connecting the past with the present; but until that time we must regard the cause of the decline and fall of the Mesa Verde aborigines as a sealed chapter in the history of our country.

An Old Departure in Theater Building

(*Continued from page 599*)

ently of one another, and on which the artist moves about in a far advanced position, in the midst of the public, no longer in front of a plane, but in space, intimately connected with his fellow-citizens around him. To this is added an external stage, likewise fixed at any level desired and which consists of three parts adjustable as well at any angle to one another. The background stage can be separated from the house and fore-stage by a laterally adjustable fire-proof iron curtain.

A Racing Car with Two Engines

(*Continued from page 599*)

a unit of four cylinders, if the engines are eight cylinder types. The engines are overhead-valve types, the cam shaft being carried above the valves and thoroughly enclosed. The method of final drive appears to be by two sets of bevel gears to a one-piece axle to which the driving wheels are attached, this construction making it possible for either engine to drive the car if the maximum power is not required and for this reason independent clutch control seems to be provided so one or both engines may be used at will.

While reports indicate that the engines are eight-cylinder types, a careful study of the illustrations by the writer indicates that these engines may be four-cylinder, sixteen-valve types; because previous experience has indicated that four-cylinder engines are capable of rotative speeds as high as can be obtained with forms having more cylinders, while with less mechanical friction loss they are more effective as far as maximum power output for a given piston displacement is concerned. In order to secure high power output, it is not unusual practice to use a number of carburetors on an engine, and in some marine racing craft one carburetor for each cylinder has been used. Unless the engines were of very small bore, it is doubtful if eight cylinders could be placed in line and obtain as compact and short engines as are illustrated. As careful inspection shows only four spark-plugs on the intake side, it would seem that the belief that the engines were only four-cylinder types is well founded. The number of ignition wires is accounted for by the use of two-spark ignition in which two plugs are used in each cylinder, a very common racing practice.

Solving the Short-Haul Problem

(*Continued from page 600*)

essary to refer further to them here. The paved highway is such a new development in the Americas that the most experienced engineers are constantly revising their opinions and judgment regarding it, due largely, of course, to the advent of the automobile and the auto truck with its trailers. Highway engineers with wide experience will verify the fact that it is almost impossible to make in advance any road census over a particular stretch of road. The development is so new that it is difficult to judge in advance how much traffic, either passenger or freight tonnage, will be diverted to the improved highway once it is built. This difficult question has been further complicated by the very rapidly increasing number of passenger automobiles and the ever-increasing number of automobile trucks with their constantly increasing tonnage capacity, and, recently, by the development of trailers for trucks. So even the most far-sighted of American engineers have been compelled to throw up their hands, and mile after mile of improved highways in the United States and Canada has been completely worn out and destroyed within a very short time after completion, due to the constantly increasing traffic.

The highway, however, permits only of the haulage of comparatively small loads by power-drawn vehicles with perhaps only a limited possible future development of the trailer and haulage in short trains behind the automobile truck itself. These trains necessarily must always be short and of limited tonnage because of the congestion, confusion and danger of accident which would occur were many long trains hauled, even if such a development were possible on other grounds.

The light railway in practically all countries in North and South America can be built and can be maintained with a smaller investment than a well paved highway. On it much longer trains can be hauled at a lower ton-mile cost. Such a railway could, as might be more advantageous, either be built alongside of and paralleling unimproved highways now existing, or following the practice of standard-gage railways could be built more directly from point to point without following the meanderings of the average highway. At a comparatively small expense, every plantation owner or farmer could have one or more switches with branch lines running to his barns or to his fields, and could load his products directly into the railway car either in the field or at his barn, hauling the car by means of horses, oxen or mules to the main line of the narrow-gage railway, where it could be switched into the train for transportation to market.

Trains could be run with greater or less frequency as the traffic might demand so that operating costs would be quite flexible with the traffic. It has even been suggested that in sparsely settled territories which might not warrant the expense for a first-class highway, the narrow-gage railway could be used, first for the construction of a cheaper improved highway which would be sufficient to carry light passenger traffic, and, second, the railway having been used for such construction could be used as a railway for the heavier traffic, both the railway and highway put together costing less per mile than a hard surfaced road would cost at the present time.

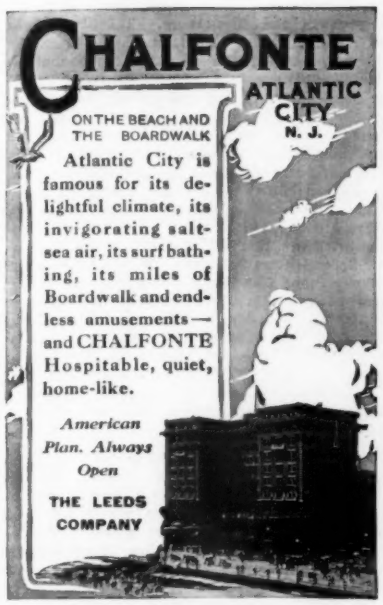
It has been my intention merely to present this skeleton suggestion of a cheap method of transportation, realizing full well the many engineering problems involved in the development of such a system, among which would be better methods of laying track; various improved types of cars for different kinds of produce and freight; the question of whether the car bodies should not be of such type that they could be transferred from the narrow-gage trucks on to standard-gage trucks at the standard-gage railway, avoiding the necessity for unloading from narrow-gage cars into standard-gage cars; the matter of more satisfactory locomotives or motive power for such railways; whether such railways should be privately owned and operated or owned and operated by the national government or the local community government. These questions would be beyond the limits of the space allowed, but I believe the whole question merits the very serious consideration of the engineers of North and South America.

The Wireless Hound—An Interesting Case of Radio Control

(*Continued from page 601*)

position and then stopping. The result is that the vehicle has not the time to respond to the rapidly altered positions of the contact drum until the final position is attained. A small green lamp, on the tip of the mast, flashes whenever the end of a complete cycle of the drum is reached, indicating to the operator exactly where he is at, so to speak.

The wireless hound weighs 185 pounds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and runs along at about five miles per hour on a level stretch. It responds instantly and positively to the signals when the proper conditions obtain. In fact, it is well to add that Mr. Glavin has found a satisfactory substitute for the uncertain filings coherer; but just what this substitute is, he will not divulge at present.

As a means of entertainment and as an educational exhibit, the wireless hound has considerable value at present. It may be that the same principle of radio control may some day be worked out for crewless tanks and other military applications—but we are getting too far ahead of our times!—By *George Gaulois.*

The Heavens in June, 1920

(Continued from page 602)

disk of the same star, rather than from a pair of stars. The vast majority of the stars, however, including all the fainter ones, are in all probability so remote, in proportion to their size, that even Professor Michelson's wonderful apparatus will be incapable of distinguishing them from mere points of light.

The Heavens

The summer constellations are now in their glory. Scorpio is well up in the south—its long tail curving down close to the horizon and bending back to end in the group of bright start which represents the sting. Sagittarius, with the Milk Dipper, is on the left, and the tangled mass of Ophiuchus and Serpens is above the two. All through this region extend the great star-clouds, crossed here and there by dark streaks which mark, as we now know, the true center of our universe of stars, and the most noteworthy region of the sky. Following the Milky Way upward and to the left, we come to Aquila and Cygnus, with Lyra above them, and then, low in the northeast, to Cepheus and Cassiopeia. The Little Bear and the Dragon are high over the pole, and the Great Bear almost as high in the northwest. Leo and Virgo occupy most of the western sky, Jupiter, Saturn and Mars adding to their luster. Boötes, Corona and Hercules, grouped about the zenith, complete the tale.

The Planets

Mercury is an evening star, and is best observed about the 29th, when he is farthest from the sun. At this time he remains visible until 9 P. M. by the sun, or 10 P. M. by the daylight saving clock, and should be easy to see. Venus is a morning star but is getting so near the sun that she is practically invisible. Mars is in Virgo, past opposition and growing fainter, but still very conspicuous, and visible until after midnight. Jupiter is an evening star in Leo, setting at about 10:30 in the middle of the month. Saturn is in the same constellation, but farther east, so that he sets an hour later. Uranus is in Aquarius, and crosses the meridian at 5 A. M. in the middle of the month. Neptune is in Cancer, too near the sun to be well seen.

The moon is full at noon on the 1st, in her last quarter at 2 P. M. on the 9th, new at 9 A. M. on the 16th, in her first quarter at 2 A. M. on the 23rd, and full again at 2 A. M. on the morning of July 1st. She is nearest the earth on the 16th, and farthest away on the 3rd and again on the 30th. During the month she passes near Uranus on the 8th, Venus on the 16th, Mercury on the 18th, Neptune and Jupiter on the 19th, Saturn on the 21st and Mars on the 24th. The last conjunction is fairly close, so that an occultation of the planet can be seen in South America.

At twenty minutes after midnight, on the morning of the 22nd, the sun reaches its greatest northern declination and enters the "sign" though not the constellation of Cancer—wherefore in almanac parlance, "summer commences."

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(14316) F. D. asks: I wish to ask your consideration of three problems. I conceived the following experiments May 5, last, but have not had time or facilities for actual experiment. If a definite quantity of water of one inch depth throughout, covering an area of a perfect square, bounded by a circle, be transferred to an area of a perfect square, retaining the depth of one inch, will not the area covered by the quart of water of one inch depth bounded by a circle be equal to that covered by the same water in a square one inch deep? The adjustable square may be made by four bars. I understand "Squaring the Circle" is to find a square with exactly the same area as a given circle; it seems probable to me that the above experiment should find such a square. If the aforementioned bars are wide enough, by forming them into a square, say, two inches by two inches, filled with water, two inches, then doubling the amount of water and arranging the apparatus as a square (or cube), the cube may be "duplicated." By placing the ends of two bars together, forming an angle (of any degress); enclosing same by an arc, and filling with water one inch deep, then diminishing the angle until the water is three inches deep, the angle is "trisected." Comparing areas of square with circle, cube with cube, angle with angle, it may be possible to obtain mathematical laws. A. Your statements of an experimental method for squaring the circle, etc., seem to be quite correct. Your results will, however, be no more accurate than your ability to construct squares and circles and to measure lines and angles. This does not go much beyond a ten-thousandth of an inch. This may be quite sufficient for the engineer, but it is not for the mathematician. He demands absolute accuracy. In 1882 it was proved by Lindemann that it was impossible to find the side of a square which was equal to a given circle. If this is so, all the other figures which you construct are equally impossible of exact determination. You cannot make a perfect square nor a perfect circle with wood or metals. In everything we make we have to say, *exact within the limits of measurement*. The squaring of the circle is among the oldest mathematical problems. The oldest mathematical document the Papyrus of Rhind, 2000 B. C., contains it. It appears in the Bible. In First Kings, Chapter 7, Verse 23, we read that Solomon made a molten sea ten cubits from one brim to the other, and a line of thirty cubits from one brim to the other, and a line of thirty cubits did compass it round about. As accurately as they could measure at that time the circumference of a circle was three times the diameter. From that time to the present men have taken an interest in this problem. The Greek scientist, Archimedes, proved this theorem, "The circumference of any circle is three times as great as the diameter and somewhat more, namely, less than 1/7 but more than 10/71." Later mathematicians have attacked the famous problem by calculating the perimeters of polygons, inscribed in and circumscribed about a circle. If two such polygons coincide their common perimeters are the circumference of the circle upon which they have been constructed. This is not a matter of construction, but of mathematical calculation. You will find it in text books of geometry. As the number of sides of the polygons is doubled an agreement in the perimeters begins to appear, and to extend in the decimal places with the increase in the number of sides. This number which gives the length of the circumference of a circle in terms of its diameter is called by the name of the Greek letter Pi. It has been calculated to more than 700 places of decimals, and will never end. Therefore, there is no exact expression for the length of the circumference in terms of the diameter of a circle. When we need only an approximate result we use 3 1/7. For greater accuracy we use 3.1416, and then 3.141592. The area of a circle is found from its diameter and its circumference. It is expressed in the formula π. If this cannot be found with mathematical accuracy then the side of the equal square cannot be found with exactness, and the cube cannot be duplicated. If you had solved the problem of the trisection of any angle by means of straight lines and circular arcs only, you would have done something which no one has ever succeeded in doing, and which was long ago demonstrated to be impossible. Any angle can be trisected by the use of higher curves, as was demonstrated about 420 B. C. by Hippias of Elis. You will find this demonstration in Sedgwick and Tyler's Short History of Science, page 65. We will send you this valuable book for $2.60. You will find articles giving the solution of the trisection of the angle in the SCIENTIFIC AMERICAN SUPPLEMENT, Nos. 1895, 1912, and in the SCIENTIFIC AMERICAN, Vol. 113, No. 13; and Vol. 114, No. 6. In these papers you will find additional matter to what is given in the Short History named above.

(14317) H. M. asks: Would you please let me know what I can put in dry cells to bring them back to life as I hear there is something they put in them which will not register on an ammeter but gives good service. A. A saturated solution of ammonium chloride in water may be put into a dry cell to cause it to give some more current after it is nearly exhausted. If the labor and time spent upon the cell is of any value, we do not believe the effort to revive an old dry cell will be profitable. Still it may be an interesting experiment. The greatest difficulty is found in getting the solution into the cell. If you can remove the pulverized materials in the cell and stir in the solution, making a wet paste again, and especially if you should add some powdered manganese dioxide to the powder in the cell the experiment would be more successful. Merely to soak into the cell some ammonium chloride solution will not add much to the life of the cell. It does not soak into the compacted powder very well, and the manganese dioxide already in the cell is mostly worn out. A current which does not affect an ammeter is surely something new.

(14318) J. F. B. says: A few days ago a Chicago clergyman, who happened to be in my office, referred to the occasional finding of grains of "corn" in Egyptian mummies, and stated that it was a well-known *fact* that this corn would grow after the lapse of these several thousand years. I promptly questioned the accuracy of his statement, at which he expressed some surprise as he has been using it, he said, as an illustration of immortality for a long while. When, however, he came back at me with the question as to how long grains of corn, wheat and other cereals *would* retain their vitality, I was unable to answer, but suggested that we leave the matter to the SCIENTIFIC AMERICAN and hence this letter. Although a very busy surgeon I have taken the SCIENTIFIC AMERICAN for a good many years and thoroughly enjoy it, though of course it has little or nothing in it of any practical value in connection with my professional work. A. We regret that we are unable to settle the question regarding the vitality of grains, especially of maize or Indian corn. The word "corn" as used in the Bible does not mean maize or Indian corn, which was unknown in Bible lands. It means any kind of grain, and possibly more frequently wheat, which was the grain of Egypt. The word corn in England is today used for our word grain. For this see almost any dictionary. Maize originally came from Peru. It is frequently found wrapped in the fabrics which enwrap the dead. The writer has seen it as taken from the Peruvian bodies as black as coal, and apparently reduced to carbon. So far as we are advised neither the wheat from the Egyptian mummy casings nor the maize from the Peruvian wrappings has ever germinated. Still we would not give a positive decision on the matter, but suggest that you refer it to the U. S. Department of Agriculture, Washington, D. C., for a decision.

(14319) W. O. L. says: What is the standard unit of value for an ounce of gold. A. We referred your communication to the Superintendent of the United States Assay Office, and they furnish the following answer. The reason that $20.67183462 was made the standard value of an ounce of pure gold was that by act of Congress, April 2, 1792, coins called "Eagles"—each to be of the value of ten dollars, or units, were to contain 247.5 grains of pure gold, or 270 grains of standard gold. By act of Congress, June 28, 1834, the Eagle was made to contain 232.2 grains of pure, and 258 grains of standard gold, which makes the value of one ounce troy $20.67183462.